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INTRODUCING THE CONTRIBUTORS

Two of the articles in this issue of SCIENCE EDUCATION were among a series of papers in the general area of suggestions to science teachers, presented before the meeting of the New Jersey Science Teachers' Association on November 10, 1944. JOHN A. KOWALD ("Specific Suggestions for Change and Improvement in the Teaching of High School Chemistry") is instructor in chemistry at Drew University, Madison, New Jersey, and is chairman of the chemistry section of the association which he addressed. LESTER R. WILLIARD ("The Obligation of Physics Teachers") is known to many as the author of *Experiences in Physics* and *Fundamentals of Electricity*.

W. H. BROWN ("Continuity for What in Chemistry Teaching?") is a former teacher in chemistry who is now Associate in the Secondary School Study supported by the General Education Board. He is working with teachers in Negro high schools in an attempt to make school work in science functional in the lives of students. It is appropriate here to quote from a letter written by a teacher in one of these schools: "We are still struggling here and, to tell you the truth, I am enjoying it. Mr. Brown came down and worked with us for nearly two weeks. Even then, we regretted his leaving . . . I'm really thrilled over our new dark room. My ninth-grade class did the work under the supervision of Mr. Brown."

A plan for a continuous science experience for high school students is suggested by PAUL F. BRANDWEIN ("Four Years of Science"), who is chairman of the biology department of the Forest Hills High School, New York City, and instructor in the teaching of natural sciences at Teachers College, Columbia University. In submitting his article, Dr. Brandwein emphasized its tentative nature and expressed his hope that readers would offer him the benefit of their criticisms, suggestions, and advice.

The paper by ALFRED F. NIXON ("The Meaning of Appreciation") is an introductory chapter of a report which he submitted in partial fulfillment of the requirements for the Doctor of Education degree at New York University. Dr. Nixon's work was done under the supervision of Professor Charles J. Pieper, former editor of this journal, who suggested to him that he prepare for publication excerpts from his thesis, which is entitled *Teaching Biology for Appreciation: The Correlation of Biology with Art, Literature, and the Social Studies.*

The article by W. EDGAR MARTIN ("A Chronological Survey of Research Studies on Principles as Objectives of Instruction in Science") was selected by Dr. Francis D. Curtis as the first to appear in the part of this journal for which he has assumed responsibility, the Department of Research in Science Teaching. Dr. Martin is critic teacher in science at the University High School, Ann Arbor, Michigan, and formerly was in charge of the biology department at Central High School, Battle Creek, Michigan. In addition to his experience in American high schools, Dr. Martin has taught in elementary schools in England.

There are two articles in this issue by members of the editorial board. R. WILL BURNETT inaugurates the Department of Trends in Education, of which he is editor, with a discussion of two recent publications on educational policy. Dr. Burnett, assistant professor of education at Stanford University, is co-author of *Biology for Better Living* and author of *To Live in Health,* textbooks for high school students. ELSA MARIE MEDER, Associate Editor, contributes a paper surveying science in the present-day world and indicating some implications of this broad view for those who teach science. Dr. Meder is assistant professor of science at the New Jersey State Teachers College at Jersey City, on leave for work with the United States Armed Forces Institute in Washington.

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SCIENCE IN THE WORLD OF 1945

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RECENT developments are rooted in older ones. The twentieth century is as it is because of events and ideals of earlier ages. A varied cultural heritage has entered into the making of the present, a heritage which includes not only the logic of the ancient philosophers but also the disputations of the medieval schoolmen. It includes as well the devices, sanctions, and ways of thinking and working that have developed during modern times.

Modern times are characterized by a tendency to examine phenomena rather than words. The spirit of the Middle Ages was one of blind faith, other-worldliness, asceticism, and resignation. The Renaissance came into being when higher values were placed upon other attributes: knowledge, individual development, rational enjoyment of life, achievement, and action. The spirit of the Renaissance sent explorers to sail uncharted oceans. It caused Galileo to devote himself to a study of things as they are. It moved Francis Bacon to proclaim a gospel of science: that knowledge and power result from interpretation of nature.

During the past three hundred years, men have applied themselves more and more to the task of interpreting the environment. They have depended less upon authority and more upon first-hand study. They have asked what the nature of things is without considering what they would like them to be. As a result, scientific knowledge has grown tremendously. Ideas which had become entrenched in the culture have been examined in the light of observations made with refined techniques, and the resulting revisions have directed further investigations. The increase of knowledge has proceeded at an even more accelerated pace.

A TECHNOLOGICAL AGE

The examination of phenomena and efforts to clarify the ways in which they are interrelated have been accompanied by attempts to apply the knowledge gained. The success of many such attempts is abundantly evident upon even a superficial glance at the everyday lives of people of 1945. Locomotives, automobiles, airplanes, and tractors are commonplace; so too are electric lights, telephones and radios, steel-constructed buildings, elevators and self-opening doors, heating and ventilating systems, refrigeration, artificial fibers, mechanically woven cloth, and machine-sewed clothing.

Statistics for production and consumption give more detailed evidence of the

extent to which the present is a technological age. For example, in 1935 alone, 413 million electric light bulbs were sold in the United States. [1] On January 1, 1940, the nation had nearly 21 million telephones in use. [2] During the calendar year 1939, more than three and a half million passenger cars and chassis were manufactured. [3]

The phenomenal achievements in technology are illustrated by reference to the short interval of time in which these commonplace things of today have been perfected. Our vast railway system has developed mostly during the lifetime of men now living. The first transcontinental railway was completed in 1869. The telephone, automobile, motion pictures, airplane, and radio are primarily developments of the twentieth century. A large percentage of the expenditure from the family budgets of the 1940's is for items unknown or not available to the generation immediately preceding this one.

Devices are continually being improved. To improve them means that new knowledge must be sought, knowledge which, when gained, may often be applied in previously unimagined ways.

An Illustration: Electronics

Radio, which still seems romantic and wonderful, is only a chapter in the story of electronics. A point at which to begin its story is with the old vacuum electric light bulb. When a wire was sealed inside the bulb and the filament was heated, electrons surged from the filament to the wire. When the wire was given a positive charge by connecting it to the positive terminal of a battery, an electric current was set up. Later a metal screen was inserted between the filament and the positively charged wire, or plate. This screen, the grid, was connected to a separate source of low-voltage electricity. As the charge on the grid was varied, the electrons streaming from the filament to the plate were controlled. They could be stopped, started, slowed down, speeded up, thousands of times per second. A highly useful new tool had been devised.

The most familiar application of the new tool is radio, which provides news, entertainment, education, police and fire protection, and acts as weather observer and automatic pilot. However, the science of electronics is being applied in many other ways, and undoubtedly will be applied in many more. The outbreak of war interrupted the commercial development of television and fostered instead the military development of radar—"radio detecting and ranging." Radar is destined to effect revolutionary changes in all kinds of navigation. In haze, fog, cloud, or night, air transport pilots will detect mountains or other obstacles as certainly as in clear daylight; ships' pilots will have unmistakable warning of other ships or of icebergs.

Radar illustrates the application of scientific knowledge in response to the demands of the times. Other electronic devices, too, have been developed to do necessary tasks. Electronic tubes are being used to guard sheets of metal on rapidly moving conveyors; to detect imperfections in heavy steel castings; to change alternating to direct current for electrolytic processes; to separate slate from coal at mines; to analyze alloys; to speed the curing and setting of plywood forms; to sort according to size all kinds of objects from oranges to tiny particles of metal powder; to insure the accuracy of engine parts—accuracy to the ten-thousandth of an inch; to measure the vitamin potency of pharmaceutical preparations; to treat certain diseases by generating heat in living tissues; to make possible the study of disease viruses by permitting magnifications of a hundred thousand diameters. The application of electronics to diagnosis, treatment, and investigation of disease holds out a promise of future improvement of health and further extension of the average length of life.

HUMAN HEALTH AND LONGEVITY

Earlier applications of scientific knowledge are evidenced in the increased human population of the earth. Three hundred years ago there were about a half billion people in the world; today there are about two billions. Yet the birth rate has been decreasing ever since records have been kept: since about the beginning of the nineteenth century. There is no doubt that proportionately fewer babies are born at present than in the seventeenth century, nor is there any doubt that many more infants survive today. Conditions for survival have been greatly improved by the application of scientific knowledge. Especially has this been true in recent years. In America of 1868, between one hundred fifty and two hundred children of every thousand born alive died without attaining their first birthday. In the early nineteen-forties, the death rate of American children under one year old was forty per thousand. [4] The improvement is ascribed largely to a marked reduction in the number of deaths from diarrhea and enteritis. [5]

Among the factors which helped to combat infant diarrhea and enteritis were improvement of facilities for refrigeration, more general purification of the water supply, more sanitary disposal of sewage, and decrease in number of house flies. For the last named, the increasing use of automobiles is in some measure responsible. Garages have replaced stables, and in garages there is no accumulation of manure in which flies may breed.

Another important factor in reducing diarrheal diseases was the widespread pasteurization of milk. Pasteurization was a direct application of principles established by Louis Pasteur regarding the presence, nature, and activity of invisible organisms.

Pasteur also laid the scientific foundation for the practice of protective inoculation. As a result, deaths from such diseases as diphtheria, scarlet fever, and typhoid fever have been greatly diminished.

Like sterilization of food products and immunization against disease, the practice of antiseptic surgery and the enactment of laws relating to sanitation are essentially applications of scientific discoveries. These and other applications have resulted in an extension of the average length of life. A baby born in America now has a life expectancy of close to sixty-four years—at least twenty-five years longer than the life expectancy of a child born at the beginning of the nineteenth century.

There is still, however, considerable room for improvement. Congenital handicaps, injuries at birth, and syphilis still cause many preventable infant deaths. Puerperal causes result in many maternal deaths. Tuberculosis, influenza, and pneumonia are not yet under control. The death rates from heart diseases, from cancer and other malignant tumors, and from diabetes are rising.

There is hope as well as opportunity for improvement. In part this hope rises from advances made in the study of endocrine glands and the consequent therapeutic use of glandular extracts. In part it rises from extension of nutritional knowledge and the possibility of stamping out deficiency diseases. If deficiency diseases were under control, effects would be far-reaching, as a single example will illustrate. In a little girl suffering from rickets, the pelvis is likely to develop imperfectly. When this child becomes a woman, she is in danger of dying in child-bed, and her children are in danger of being injured at birth. Application of knowledge about vitamins may be expected to reduce maternal and infant mortality.

A further hope for improvement lies in the "domestication of micro-organisms." Penicillin is only one of many newly-discovered substances, produced by micro-organisms, which are capable of wide use in medicine. One such enzyme, for instance, is reported to be so powerful that it stops bacterial growth when used in a dilution of two to ten parts per million of

the solution in which the bacteria are growing.

Advances in controlling respiratory diseases may be expected to come from application of engineering knowledge. Engineers report that they have found a way to clear indoor air of airborne germs by the use of ultraviolet rays.

To deal with the marked increases in deaths from malignant tumors, diabetes, and heart disease, new knowledge is being sought. Because these ills are diseases of maturity, the increases may be attributed in some measure to the changing population structure. People who might have died in infancy are living longer, to die, perhaps of "heart failure" in old age.

The proportions of young and old in America are changing. The median age of the population is increasing: in 1920, it was 25.2 years; in 1940, 29.0 years. The same fact may be differently expressed: in 1920, half of all Americans were under 25.2 years of age; in 1940, half the population of America was aged 29 or older.

It is probable that in the future there will be greater emphasis upon control of diseases of maturity and later life, with consequent further increase in life expectancy, larger proportions of older people in the population, and greater numbers of people on earth.

THE PRODUCTION OF FOOD

The world of the present is a world in which there are more people living at one time than ever before. More people need more food. As population continues to increase, so must the production of food. The relation between agriculture and population growth is a basic one.

There would seem to be two ways to increase food production: one, to bring under cultivation land at present unused; the other, to increase the yields of acres now being farmed.

Certain regions of the earth cannot be considered of much value for agricultural production. These regions include areas which are too mountainous for farming and regions which are too cold, such as the extremes of the artic and antarctic zones. In addition, some sections are too dry for successful use as farm land: 25 per cent of the earth's land surface has a mean annual rainfall of less than ten inches; another 30 per cent has between ten and twenty inches. Much of this land cannot be successfully irrigated because there is insufficient water. Some of it, however, has been transformed into extremely productive land by irrigation. In the United States, irrigation has made available more than thirteeen million acres of farmland since 1900.

Factors Contributing to an Increased Food Supply: (1) *Mechanization*

In general there is more promise of an increased food supply in the better use of farmland than in the farming of hitherto unused land. Several factors may contribute to better farming practice. One is the increasing use of farm machinery. Mechanization alone is said to be responsible for a sixfold increase in corn yield per man hour since 1910. [6] One man with the proper equipment can make a good living on what would otherwise be subsistence acreage.

The tractor is the dominating machine in farm mechanization. It was used as early as 1910, but the early models were cumbersome, expensive, and limited largely to draft work. Today there are light, rubber-tired tractors to which many specialized devices may be readily attached. These new tractors are useable on small farms and for many purposes.

There are many other kinds of farm machinery, among them harvesters and combines, hay choppers, cultivators, manure spreaders, fertilizer placers, power sprayers, field ensilage cutters, balers, planters, and plates for accurate seed placement.

Another phase of farm mechanization accompanies the spread of rural electrification. Electric power on the farm not only

performs household tasks as it does in urban homes, but it also pumps water for irrigation, mixes feed, runs milking machines, sterilizes dairy equipment, warms chick incubators, and lights laying houses.

The "industrial revolution" has come to the farm. Farm mechanization is proceeding rapidly. Acreage is being used more efficiently. Crops are being harvested at their prime and thus with minimum loss. In general, production is being raised to new levels.

Factors Contributing to an Increased Food Supply: (2) Improved Fertilization

Plants grow only if certain inorganic substances are made available to their roots. As plant production increases, the supply of minerals in the soil is decreased. Almost eight and a half million tons of nitrogen, phosphorus, and potassium are removed from the soil each year in harvested crops. However, this amount is only a fraction of the total loss. Far greater amounts are removed by processes of erosion. To maintain soil fertility, then, two things are necessary: first, to put minerals into soil to replace those removed by crops; and second, to reduce soil erosion as much as possible.

Many elements are essential to plant growth, but plants need far greater amounts of nitrogen, potassium, and phosphorus than of the other essential elements. Vast supplies of all three of these minerals are readily available. Yet within the past fifty years people have sincerely feared serious shortages of two of them. In 1898, Sir William Crookes predicted that by 1931 there would be a world-wide wheat famine resulting from lack of nitrogen fertilizer. He overlooked the possibility of maintaining the nitrogen content of soil by growing legumes, and based his prediction upon the rapid depletion of the great beds of Chile saltpeter, at that time the world's chief supply of nitrogen. With the perfection in 1912 of the Haber process for fixing atmospheric nitrogen, it became possible to manufacture nitrogen fertilizer far more readily from air than from nitrate rock. There seems to be no danger of ever running out of nitrogen for fertilizer.

During the first World War a potassium shortage developed in Allied countries, for prior to that time nearly all potassium came from great German deposits. A serious search was instigated for new supplies of potassium, and great accumulations were discovered in many parts of the world. The supply now appears to be sufficient to last far into the future. Most igneous rocks contain large proportions of potassium.

Plants need other minerals, but in quantities so small that there is little question of a plentiful supply. The effects of various minerals and mineral deficiencies on different plants are being determined by the method of soilless culture. Plants are grown with their roots in sterile water or sand to which known amounts of minerals have been added. As a result of application of knowledge gained from such studies, plant deficiency diseases are being prevented, and crop failures avoided.

Furthermore, farmers are learning better ways to use fertilizers. Soil analyses indicate what elements a soil lacks and what proportions of each necessary element should be applied. Modern equipment makes it possible to place fertilizer so that seed germination will not be impeded and weed growth will not be stimulated.

Factors Contributing to an Increased Food Supply: (3) Erosion Control

Processes for checking soil erosion are coming into widespread use. The value of these procedures is evidenced in increased crop yields. In certain southern states the use of winter cover crops was followed by an increase of twelve bushels of corn per acre. In the western Corn Belt increases of five to twenty-three bushels per acre were attributed to contour farming. About fifteen million acres of corn

grown annually on sloping land in this region could be farmed on the contour. The potential increase in corn production from this practice appears to be of considerable proportions. Crop rotation, too, has had a beneficial effect upon corn yields. In Illinois, yields were found to be increased through systematic crop rotation by ten to fifteen bushels per acre. [7]

The spread of the practice of crop rotation has resulted in greater acreages of certain crops. The substitution of high quality legumes for other hays has, by maintaining and increasing the nitrogen content of the soil, resulted not only in increased tonnage of hay but also in higher feed value per ton. Crop rotation similarly results in greater acreages of more nutritious human food. Soybeans, for example, not only are better for the soil than corn, but are also better for people.

Another important effect of crop rotation is improved control of the insects and nongreen plants that attack crops. However, crop rotation can be a two-edged weapon in the warfare against competitors. To be effective, its use must be based upon accurate knowledge of the life cycles of insects and nongreen plants. Otherwise, their spread may be fostered rather than checked.

Factors Contributing to an Increased Food Supply: (4) *Plant Breeding*

Nongreen plants which secure their food from cultivated crops may greatly reduce crop yields. In 1938, the corn yield in the United States was reduced by more than ninety-five million bushels as a result of the action of a single fungus, a smut. In the same year, more than eighty-five million bushels of wheat were destroyed by a rust. These losses would have been avoided if the plants had been immune to the diseases. The breeding of disease-resisting varieties of crop plants is an important factor in the production of more food from the same area of land.

In addition to the development of more resistant strains, plant breeding may improve crop quality. It has been estimated that in 1938, forty to fifty million more bushels of wheat were grown in the United States than would have been possible had the same acreage been planted with the varieties of wheat known in 1890. In 1942, the United States corn crop was greater by 629 million bushels as a result of the use of hybrid seed.

The story of hybrid corn is a story of the application of the science of genetics. Corn is normally cross-pollinated, and consequently it is not possible to select seed that will breed true for desired characteristics from usual plantings. However, it is possible to use ears from good plants as seed stock for the next year. The plants grown from the seed are artificially self-pollinated, and inbreeding is continued for five to seven years. When two such inbred strains are crossed, desirable characters of both strains are likely to be present in the first generation. Unfortunately, the characters diminish in subsequent generations. Among the desirable corn hybrids which have been developed are plants which resist attacks of the chinch bug and the corn root worm, plants with especially sturdy stalks that stand up well through wind storms, plants with long roots that help them to survive dry weather, and plants which bear ears at the level from which they can best be harvested by mechanical corn pickers.

Factors Contributing to an Increased Food Supply: (5) *Improved Livestock*

Chickens that lay three hundred eggs a year, hogs that efficiently convert feed into pork roasts and bacon, cows than give thousands of quarts of milk yearly: these and other accomplishments have resulted from attention to the improvement of livestock.

The improvement of animals involves disease control, better feeding, and more

careful breeding. A valid reason for improving livestock is the hope it offers of more and better food for human beings. For example, milk production can be increased and quality can be improved by breeding better cows, supplying their nutritional needs, and eradicating the diseases which attack them.

Tuberculin-tested herds are commonplace now, and bovine tuberculosis has been practically wiped out of the United States. Efforts and methods similar to those developed in the attack on tuberculosis are being used to combat Bangs disease. Vaccination of calves against this disease is being tried with apparent success. An enzyme, tyrothicin, one of the substances produced by a " domesticated " microorganism, is being employed in the treatment of mastitis, an infection of the cow's mammary gland.

Much work has been done on the nutritional needs of animals, and much remains to be learned. Early research in animal feeding was concerned with the protein-energy ratio of the intake and with the digestibility of the feed. Later studies consider vitamin and mineral requirements; the effects of deficiencies; the most effective use of forage, pasture, hay, and silage; and the effects of harvesting and storage methods upon the quality of feeds.

Cattle breeding is based upon knowledge of the mechanism of heredity and upon careful records of production. Of the cows bred for milk production, one has attained a record of 19,500 quarts of milk annually. Forty million such cows could supply everyone in the world with a quart of milk every day.

There are some 235 million cows in the world today and by no means enough milk for every person to have an adequate supply. If each of the two billion persons on earth were to meet even the minimum standard (for adults) of a pint of milk a day, the average annual milk production of each cow would have to be about 1,550 quarts. This seems low enough when compared with the record of the champion, but very high when compared with the average production of the seventy million cows in India—350 quarts per year. It seems reasonable when compared with the average annual production of American cows—2,200 quarts; or of prewar Dutch cows—3,500 quarts.

The problem of getting more milk seems to be primarily one of getting better cows. To a large extent this means using better bulls as sires, for the ability to produce milk is apparently inherited through the male. The development of techniques of artificial insemination has made proved sires far more widely available than possible when dependence is placed on natural mating. By using these techniques it is possible to insure inheritance of the factor for good milk production.

Technology and Food Supply—A Summary

Tractors, combines, and corn pickers; fertilization, crop rotation, and contour plowing; hybrid corn and new kinds of wheat; the testing and breeding of animals—these and many other devices and practices are aspects of technology, a social force which challenges men to use its benefits for the good of humanity. While there can be milk for all, should babies anywhere be ill-nourished? While there can be bread for everyone, should human lives be lost through starvation?

More people require more food. More food can be produced. The limits are not in sight.

MATERIALS AND ENERGY

More people require more possessions, also: more pots and pans in which to prepare their food, more stoves and refrigerators, more knives and forks and dishes, more house furnishings and more houses. More people desire more telephones and radios, more automobiles and airplanes.

To make these things and others, materials must either be taken from the earth's crust or grown on its surface.

Materials of Many Uses

The use of biological substances in the manufacture of durable goods is increasing. Wood, of course, has always had many uses. Now it has even more, for now it can be twisted and bent, molded and toughened. Even airplanes are manufactured from wood today, not because the necessary metals are lacking (for they are not) but because plywood can be readily molded. Molded plywood planes are said to be faster and subject to less vibration than metal planes.

Fabrication by molding permits enormous savings in time and labor. As a result, materials which can be molded are highly desirable. Synthetic plastics have this property. They can be molded almost instantaneously and formed accurately to the thousandth of an inch, and they require no finishing.

The raw materials for the synthesis of plastic substances are readily available. Many plastics have a cellulose base; and cellulose is found in the walls of all plant cells. Some are compounded from proteins, especially from the proteins of soybeans and of sour milk. Others depend upon reactions between phenol and formaldehyde, both easily manufactured in huge quantities. Still others are made by the interaction of two very plentiful gases, carbon dioxide and ammonia.

There seem to be no practical limits to the quantity of synthetic plastics which can be produced. Similarly, the production possibilities of other synthetics—fibers and rubber, for example—seem unlimited. The use of synthetics will spread, not in an effort to conserve natural products, but because of the desirable properties of the synthetics. This point was strikingly demonstrated by the rapid adoption of nylon hosiery in place of silk. Synthetic rubber, too, has been found to be superior to the natural product for certain purposes, notably for use in automobile tires.

The Call for Metals

More than ninety per cent of the metal produced in the world is iron and steel. Tremendous quantities of iron are being used: more than one hundred million tons were moved from the Mesabi range in 1943 alone. Yet there seems to be no reason to fear a serious shortage. At present much of the ore mined in America contains 50 per cent of iron, but it is perfectly possible to use ore of far lower concentration. The reserves of ore containing 25 or more per cent of iron are such that, at the present rate of use, there would be adequate supplies of iron for many thousands of years to come. Technology has the means to send the curve of iron and steel production steadily and smoothly upward.

There is justification for placing faith in the use of low-grade ore. Formerly copper ores were considered workable if they contained 4 per cent of copper; now ores are used which contain only 1.5 per cent or even 1 per cent of the metal. Doubtless ores of lower concentration will be used in the future. It is probable that there are adequate supplies of copper for centuries to come in ores with a copper content of 0.5 per cent.

Nowadays, metals which were once a rarity are being widely used. Aluminum, for example, is replacing copper in many transmission lines. The replacement is possible because the electrical conductivity of aluminum is high—61 per cent that of copper. Although an aluminum wire must be of greater diameter than a copper wire to carry the same load, the specific gravity of aluminum is so low that conductors with the same capacity made of aluminum are much lighter in weight than those made of copper.

Aluminum is finding a place in many industries. Most important at present is its use in the various branches of the transportation industry, for here the strength

and low specific gravity of the metal are distinct assets. By its use, the dead weight of a vehicle may be reduced, thus making possible more rapid acceleration and a marked saving in the energy required to remain in motion. Consequently aluminum is used in the construction of aircraft, of locomotives, of automobiles, buses, and trucks, and of ships.

Aluminum can be produced in almost any quantity. It is the most abundant of all metallic elements found in the earth's crust. But even more abundant than aluminum is magnesium. The great reservoir of magnesium is not the earth's crust, but its oceans. Magnesium comprises 0.1 per cent of sea water. Existing facilities are able to produce great quantities of magnesium. These plants were an early answer to the requirements of the second World War, for, until better substances were found for the purpose, magnesium was essential to the manufacture of incendiary bombs.

Magnesium is probably a metal with a future. Its lightness makes it of potential value in the airplane industry, for it is only two-thirds as dense as aluminum. There are problems to be solved before it can be put to use, however, notably problems concerned with alloying and with preventing corrosion.

The expanding production of both aluminum and magnesium which came with wartime demands required enormous amounts of direct current electric energy. Ten years previously, this requirement would have necessitated building great rotary converters, using large quantities of steel and copper. It was possible, however, to use electronic tubes to convert alternating to direct current electricity, with a net saving of 24,000 tons of steel and four million pounds of copper.

The saving of metals in this instance is only one illustration of economies that may be expected in the future. For example, there is promise now of wireless transmission of power. Such a development would not only do away with thousands of miles of wire and cables and with the need for thousands of tons of metals of high electrical conductivity, but might be expected to inject new flexibility and efficiency into the whole matter of production and distribution of goods and services.

Supplying Energy Demands

A vast amount of energy is required to maintain high levels of production. The technological age has thus far depended for energy largely upon the fossil fuels in the earth's interior. At times these fuels have been produced and used wastefully. But there is no reason why they cannot be produced more efficiently and used more wisely. Furthermore, they are not the sole available source of energy. Water power is used to generate electrical energy, and there is far more water power available than has ever been harnessed. Tidal energy has been tapped experimentally. The energy of the sun has been utilized directly in solar engines. Moreover, unfathomable amounts of atomic energy can be obtained by recently developed and carefully guarded techniques.

Far more prosaic than splitting atoms is the manufacture of alcohol from plant substances, yet this procedure, too, will probably contribute to future energy supplies. Internal combustion engines have hitherto been run almost entirely by petroleum products; they can be operated by alcohol. In fact, an engine has been built which operates on a mixture of 40 per cent alcohol and 60 per cent water with a greater efficiency than any Diesel or gasoline engine has attained.

A HIGH CALLING

The world of the present is a world in which more food is being grown than ever before has been brought forth. It is a world in which goods can be produced of a quality never before known and in quantities undreamed of in all history. It is a

world in which energy can be supplied in hitherto incomprehensible amounts.

Consideration of this world suggests that no one need be ill fed, inadequately clothed, or poorly housed. It brings a vision of what can be: nourishment for starving millions, clothing for those who are ragged, healthful homes for those who huddle in shanties or ramshackle tenements—freedom from want. But the vision has yet to be translated into actuality. To do this is the high calling of the present age.

The challenge is to make democracy work, to put the earth "at the service of all mankind." The technological character of the present age means that by and large men are committed to the satisfaction of human needs through the control and transformation of the environment. But there is danger in even this commitment. In an effort to exercise control over nature, men forget that other persons are more than machines, more than markets. "Human resources" are considered, in large measure unconsciously, on a par with biological resources or with physical resources. Men think of other men as material for manipulation. Achievements are used for personal aggrandizement, power, and soft ease; for exploitation of fellowmen; for destruction.

A technological age can be dangerous. One thing stands guard against its danger: an intelligent loyalty to the democratic ideals of the welfare of all men everywhere and the worth of each individual. When mutual understanding and respect begin to be the order of the day, achievements will be used more and more for building a better world for everyone.

To this end there must be greater concern for human beings as individuals with varying abilities, interests, outlooks, problems, and responsibilities. To this end, too, there must be more attention to the problems of human beings as members of national, religious, racial, and economic groups. In America, as elsewhere, there are fallacious doctrines and common misunderstandings regarding each of the many groups in the population. No single factor in the present age seems so certain to lead to disaster as the hatred of group for group.

In the world today no person or group of persons can live alone. The lives of individuals are linked by many diverse bonds. Community depends upon community. Farmer and townsman are neighbors. Neighborhoods are not circumscribed by political boundaries. In terms of travel time the whole earth is smaller now than the thirteen United States were when George Washington became their President. Isolation is no longer a possibility.

IMPLICATIONS FOR EDUCATION

The developments of technology lend emphasis to the importance of a type of education that leads people to recognize the possibility of improved living conditions and equips them with skills necessary for productive labor and the attainment of purchasing power. As more and more people acquire such skills, education, culture, leisure, amusement, and travel for everyone will become more likely.

Experience has indicated that the American nation is capable of vast production and of sustaining an annual income of 110-120 billion dollars. Therefore, it is only reasonable for all people, since they have the ability to produce, to want to attain a high standard of living. The maintenance of the present large national income is imperative; for, among other things, there will be the servicing of an enormous debt, increased cost of government, and extraterritorial expenses in the post-war period.

Some Basic Understandings

If a high level of production and income is to be maintained, a thorough understanding, on the part of the general public, of the problems and possibilities of industry must be developed. People must understand what 110-120 billion dollars means in terms of natural resources. There must be real understanding of wealth in terms of

our capacity to utilize natural resources and of the importance of distributing the products of industry to all who desire them. This understanding will be dependent upon recognition of the great opportunities for conversion of raw materials and energy into refinements of food, clothing, and shelter. It will involve an understanding of the nature of jobs—that genuine jobs result when productive work is to be done. It will be of value as it is developed along with, and in the light of allegiance to, democratic ideals.

Maintenance of individual and public health and the peaceful resolution of social differences, as well as the wise use of natural resources, must grow out of people's knowledge and understanding of natural laws. Education designed to prevent poverty, disease, and crime will assure more stable social conditions than any amount of money and effort devoted to stamping out such evils.

If a workable understanding of nature, man, resources, and manufactured products is to be acquired by a majority of the people, the schools must recognize their responsibility for developing it. They must strengthen their efforts in this direction. The findings of science hold tremendous potentialities for the education and comfort of mankind. These potentialities may be recognized and understood only as a result of a functional education in science.

The Methods of Science

That such education has not yet been achieved is evident upon consideration of contemporary confusions and conflicts. Living standards are raised; poverty is induced. Natural resources are conserved; the earth is scorched. Goods are widely distributed; possessions are destroyed. Knowledge is fostered; misinformation is broadcast. Diseases are defeated; death is disseminated.

Present conditions resulted in large part from technological advances, which in turn depended upon the interpretation of natural phenomena by the inductive and experimental methods of science. If increasingly intelligent direction of the increasingly complex activities of mankind is to be attained, the methods of science which so largely produced the present social scene must be used in it.

Obviously, social phenomena are inherently more complex than those in the domain of natural science; thus there is necessarily some confusion as to how people may proceed to apply scientific methods in this realm. Social events are dependent upon physical, biological, psychological, and historical factors. Scientific methods cannot be applied in the same way as they can to the less variable "natural" events. But they can be applied. As a matter of fact, they are being applied daily, although imperfectly. Everyone acts on inferences made from his observations and thus discovers his errors. Everyone is directed in his inquiries by generalizations and modifies those generalizations in the light of his experiences.

Advances in natural science have resulted from an unbiased attack upon problems. In the same way social problems may be attacked by asking what can be honestly believed regardless of prejudice or of the dictates of authority. A critical examination of facts, a careful review of all available evidence, undertaken in this spirit, will necessarily lead to a replacement of traditional generalizations with revisions which will permit fearless acceptance of new knowledge, and which, moreover, will serve to direct further investigation leading to the formulation of constructive programs of social action. Practical decisions must be made even though evidence is incomplete and data are unreliable, but recognition of the inadequacy of such bases will lead to revision of judgments when new evidence is discovered. This is the fundamental procedure which has made natural science a self-corrective

system. There seems to be no insurmountable obstacle to the extension of the same principles into many other phases of human affairs.

The Problem of Values

Scientific methods can provide knowledge of facts. These methods can show the consequences of the application of facts. They can make possible the examination of ends to be achieved through knowledge. They permit anticipation of the future.

The world of the future will be no better than the men and women who live in it. If men and women of the future order their lives on the principle that "my good is my good and your good is yours," there can be no realization of the democratic ideal of freedom. But if they reject preoccupation with self and choose instead identification with the rest of mankind, then there will be freedom indeed.

Science points the way to values. But it cannot force their acceptance. It cannot make certain the attainment of a desired goal. It cannot make life other than an adventure. It cannot produce equilibrium. But it does "minimize the shock . . . of the uncertainty of life." [8] It does offer mankind a chance to become socially intelligent.

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THE OBLIGATION OF PHYSICS TEACHERS

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OF ALL the sciences taught in high school I believe that the physics course has been changed the least in the past fifty years, and probably rightfully so. Before a student can go on in any scientific field, he has always had to understand certain basic principles. Density, Archimedes' principle, Hooke's law, Bernoulli's effect, measurement of energy, Ohm's law, are only a few of the principles a student must have had, so that he might successfully pursue work in any scientific field. I have no recommendation for a change in the content of the physics course, although I would like to see the Wheatstone bridge included in the college preparatory course.

A basic understanding of many of the physical principles is valuable to any one. Take the problem of home appliances. All you need is to look around your neighborhood and you will find people paying too much for too little. I, personally, know one individual who spends twice as much for his fuel as he would need to do, if he understood and applied certain physical principles related to the transference of heat. Similar examples of waste, through inefficient operation, can be found in the use of electricity, the operation of an automobile and other uses of energy. My first recommendation, then, is that all students be given a course in physics on a level of

their individual ability. For the operation of the simple machines in our homes and the procuring of maximum return for money spent in such, every student should have a knowledge of the simple fundamentals of physics.

My second recommendation follows. I visited the New York World's Fair many times, and found myself, on many of these visits, ending up late in the afternoon at the Ford building. The thing that intrigued me was the large revolving cone in the center of the building. Many of you may remember it. I shall attempt to recall to you the appearance of the cone and its meaning.

Near the base of the cone were miniature mines with manikins simulating the removal of the coal and the ores from the ground. At the next level, were the smelters that refined the ore. Plantations, from which rubber, wool, and other products are obtained were also shown on the cone. Higher up on the cone were the factories that produced the different materials needed to build an automobile. A very dramatic voice explained that out of the earth, man obtains the fuels and materials necessary for him to build. As each successive operation on the materials is made (operations involving man-hours of work), the materials become more valuable.

Naturally, on the top of the cone there was a Ford automobile. But on the top of that cone we may also place a tank; we may place a hospital, or a munition factory. We may even place a palatial ocean liner or a battleship. We may place a college or a training camp for soldiers. Thus, we may take fuels and materials from the earth and use man-hours of work to make things for destructive purposes, or things for constructive purposes. The types of things that are placed on the top of that cone, and their possibilities for good or evil, will determine whether we shall better or lower our standards of living. The raising or lowering of our standards is a matter of definite choice. We must see that there is among our dreamers or inventors, manufacturers, and users, this desire to lift the standards of living. And, in the school, we must concern ourselves most urgently with the potential users, whose desires will finally urge the dreamers to plan, and the manufacturers to embody the objects that they want or need.

We, as physics teachers, have an obligation—to get across to the students not only an understanding of physical principles but also a desire to use their knowledge for constructive purposes. We cannot drop pre-induction training as long as there is a war that must be won, but we can start some of these students, who will be our future leaders, thinking in terms of a national and universal desire for high standards of good living. This will necessitate prolonged thinking along constructive rather than along destructive lines.

Public education is anchored in the nature of civilization as unfolded. It is thus closely associated with the ideals, policies, and institutions of government and economy, as well as the arts and sciences. Although some forms of private education may be far removed from the hard world of practice, public education can maintain no such isolation. Many professional representatives, it is true, may properly concentrate on schoolroom procedure, methods, and testing, but the leaders who determine the content and objectives of instruction must work under the immediate impacts of society—its needs, drives, and demands.—"The Unique Function of Education in American Democracy." Educational Policies Commission, National Education Association, Washington, D. C., 1937, pp. 66-67.

SPECIFIC SUGGESTIONS FOR CHANGE AND IMPROVEMENT IN THE TEACHING OF HIGH SCHOOL CHEMISTRY

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BEFORE any suggestions for change in the teaching of chemistry are proposed, a brief appraisal should be made to ascertain whether present practices and content meet the functional needs of high school students of chemistry. If the functional needs of high school students are met by the conventional course in chemistry, then no significant change should be proposed and this report would therefore be brief.

However, many important changes have been taking place in education. In a report by Samuel Ralph Powers of Columbia in 1942 [1], it is shown that one significant change taking place in high schools is the trend away from emphasis on college preparation towards emphasis on education that is immediately functional.

In 1900 a high school course in chemistry may have had as its single objective the college preparatory function. This was justified because in 1900, according to the U. S. Office of Education, 75 per cent of the graduates went on to college. Today this objective cannot be entirely justified, because according to the U. S. Office of Education not more than 15 per cent of the total secondary school population now continues beyond the 12th grade.

It is not my intention here to minimize the high school chemistry course whose chief function is college preparatory. There are instances in which this function may rightly be the paramount aim, and the conventional, rigorous course in high school chemistry, emphasizing theoretical and quantitative relationships may be entirely satisfactory. I do not direct my remarks to this group necessarily.

But if only 15 per cent of the secondary-school population goes on to college and a smaller percentage of these students continue with chemistry in college, then the college preparatory objective certainly will not be functional for the 85 per cent of the students whose objectives are identified only with the common secondary educative experience. If chemistry teaching in the high schools is to expand to any great extent, it will draw upon this larger group for its enrollment by adjusting itself so as to provide functional chemistry for these students.

The conventional sequence of topics in chemistry such as water, oxygen, hydrogen, air, nitrogen, oxides of nitrogen, organized under the usual headings of occurence, preparation, properties, compounds and finally uses, is designed for college preparatory students. This sequence is used because it is the order in many high school chemistry textbooks which are chiefly college preparatory in nature. The important applications relating to the problems of everyday living about the home and community are not sufficiently stressed. Yet it is this phase of chemistry which is of most value to the student who does not intend to go to college.

WHAT IS FUNCTIONAL CHEMISTRY?

A course in chemistry which would be functional to the general student would increase his knowledge concerning such topics as the light metals, alloys, synthetic fibers, vitamins, high octane gasoline, fertilizers, synthetic rubber, corrosion, sulfa drugs, medicinals, the chemistry of the soil, and the chemistry of our strategic materials. Such chemistry would motivate the student to look into the underlying chemical theories as well.

The study of high school chemistry should result in the acquisition of such information and such techniques as would be of some worth to the student, his family and the community. Certainly the study of soils, soil testing and fertilizers, and the study of foods and vitamins would be useful to him and to his family. In Elizabeth, New Jersey, I believe, a group of students in the chemistry class developed the technique of soil testing to the point where they were actually making a contribution to the community by analyzing soil samples and recommending certain commercial fertilizers for various types of soil.

In doing so they learned to read the labels on the commercial fertilizers and to understand their meaning. The ability to read labels intelligently in this and other fields of chemistry is a worthwhile outcome of chemical education on the high school level. Work experience of this sort is not without its recreational and avocational values.

Further studies might be encouraged in soilless plant growth, experimentation with the effects of certain hormones, vitamins, and other nutrient or regulatory substances on plant and animal life, and are suggested. Such studies are not studies of pure subject matter, but correlated as they are in this case with biology, are of even more value. The study of chemical plant hormones has, for example, been of great significance in the propagation of cuttings from pine trees which produce exceptionally large quantities of turpentine. Pine cuttings can be rooted only by means of these rooting chemicals. The process can be effectively demonstrated. Functional chemistry overlaps into other subject matter fields. The study of nutrition cannot be divorced from biology; the study of antiseptics involving, as it does, inorganic and organic chemicals cannot be separated from bacteriology; and, as a further example, the study of radioactive elements should be related to the phenomenon of X rays, the newer physics, and even cell structure, colloid chemistry, and genetics.

In connection with the study of X rays it may be pointed out that X rays scatter electrons on contact with the tissues to which they are exposed. The electrons thus liberated neutralize the positively charged colloidal particles of albumin in the chromatin granules of the nuclei of cancer cells more readily than the colloidally charged albumin particles of the surrounding normal cells. This is due to the fact that the albumin particles in the rapidly growing cancer cells do not acquire as great a positive charge as the albumin particles in normal cells. Therefore, the nuclear organization of cancer cells is more readily disrupted by X rays and radioactive elements than the nuclear organization of normal cells.

Greater emphasis on the chemistry of the body, the chemistry of foods and nutrition and vitamins should be made and laboratory experiments may be performed for this purpose in the chemistry and biology laboratories. The outcomes of such study would be of definite value to the student. By actually working out biochemical experiments the student will also gain a greater appreciation of the part that the expert plays in modern life, and of the fact that today one needs to depend more and more on the experts in many fields for his very existence. For example, the modern physician depends on the biochemists who devise sensitive physiochemical reactions to diagnose functional disorders, and on the chemical specialists who synthesize organic compounds which are capable of selective destruction of pathogenic bacteria.

The chemistry course should be related to the many industries about it so that the student may acquire first hand experience of the industrial world about him. It may even be that work experience in chemical industries may be part of this functional high school education in the future. New Jersey, for example, is one of the important

states in chemical manufacture and refining. In this state are plants producing pharmaceuticals of all kinds. Modern plastics are being produced here which will help conserve our mineral natural resources. In as much as many plastics can be made from plants that grow in the soil, the chemistry student should be able to see the economic significance of this fact. This state is leading in the production of fuel gases which are manufactured from coal, and is a large refiner of 100 per cent octane gasoline. Synthetic butyl rubber is manufactured from olefins and butadiene. If the study of chemistry in New Jersey high schools is related more closely to these industries, the teaching of chemistry will be more functional.

STRESS ON APPLICATIONS

In order to make the chemistry course more efficient, the important applications should be stressed. In the study of fuels, to give an illustration, more emphasis should be placed on the potentialities of coal and petroleum as raw chemical materials, on the useful products obtained from coal and petroleum in actual practice and in the research laboratories, on ways of conserving these natural resources, on the source and composition of the fuel gases. Questions should be raised as to what are the characteristics of good liquid fuels used in the home, the automobile, the Diesel engine, and the airplane engine. What is meant by cracking, flash point, antiknock and high octane value? What are the precautions against and the emergency treatment for carbon monoxide poisoning?

Experiments relating to applications on this same topic might include study of carbon as a reducing agent, carbon dioxide, baking powders, types of fire extinguishers, destructive distillation of crude oil and coal tar, flash point of kerosene, and dust and gasoline bombs.

In connection with ethylene, the epinastic response of tomato plants in the presence of gas and as a test for gas leaks can be readily demonstrated in an ordinary laboratory period. In fact one can demonstrate the natural emanation of ethylene gas from ripe apples, bananas, and other fruit. Such experiments set the stage for the discussion of the principles underlying the commercial process of coloring and ripening of fruits, such as bananas and citrus fruits, by ethylene gas. These are a few specific illustrations which may provide effective and dynamic classroom activities.

A LIST OF TOPICS

In order to make the high school course in chemistry functional the teacher should whenever possible utilize the following topics as worked out alphabetically by the Committee of Chemical Education of the American Chemical Society:

Adhesives: gums, paste, dextrin, glue, casein, water glass

Artificial stones: lime, plaster, mortar, hydraulic cement, concrete, stucco, plaster of Paris

Beverages: charged water, soda, mineral infusions, tea, coffee, artificial fruit juices, fermentation

Clay products: brick, pottery, stoneware, chinaware, porcelain

Cleaning agents: oxalic acid, hydrochloric acid, sodium hydroxide, soap, carbon tetrachloride, benzene

Coal

Dyeing

Explosives: black powder, nitroglycerol, dynamite, guncotton, trinitrotoluene

Fertilizers: soil fertility, elements needed by growing plants, photosynthesis, carbon and nitrogen cycles, use of limestone and phosphate rock

Foods classification: starch, preparation from corn, cooking to dextrin and to paste, hydrolysis to glucose; sugars—preparation and refining of beet and cane varieties, conversion to caramel, inversion; fats—olive oil, cotton-seed oil, butter, oleomargarine, hardening oils by hydrogenation; proteins—albumins, casein, gluten, peptones, gelatin; vitamins

Glass: crown, flint, lead, special glasses, coloring glasses

Ink: iron ink, organic dyes, carbon ink

Leavening agents: baking powders, yeast, soda

Matches

Alloys: iron, copper, aluminum, lead, ornamental metals, bronze, brass, solder, type metal, bearings, fusible steels

Nitrogen fixation: relation to fertilizers, explosives, dyes

Paint and varnish: oil paints and driers, varnish, shellac, linseed oil, oilcloth, linoleum; pigments—white lead, red lead, iron oxide, lead chromate, zinc white

Paper

Petroleum

Photography: blueprints, plates, films, prints, toning

Preserving: sterilizing, pasteurizing, pickling by salt and sugar, common chemical preservatives and tests for them

Refuse disposal: sewerage, garbage, fermentation, putrefaction, civic problems, disinfectants and deodorizing agents

Silicates

Textile fibers

Wood

Poisons and common antidotes

These topics have been suggested for a minimum course in high school chemistry. Particular topics may be selected, expanded, and studied as the situation arises. The teacher should consult the literature, visit local industrial plants, select films, devise appropriate exhibits, demonstrations, projects, and laboratory experiments for the suggested and up-to-date topics which are related.

Through many applications such as these, teaching of chemistry may be made more functional without eliminating in any way truly scientific methods and mastery of the principles of chemistry. Chemistry in the high school for the general student is functional if it increases his appreciation of the cultural heritage with which he is endowed; if it provides useful applications related to his personal, social, and community life; if it enables him to acquire techniques which are useful to him; and, finally, if it provides useful work experience.

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CONTINUITY FOR WHAT IN CHEMISTRY TEACHING?

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TEACHERS of high school chemistry face a stubborn problem when they try to organize the instruction in their classrooms to permit direct study of issues and problems of immediate significance in the lives of their pupils. Pupils entering a course in chemistry for the first time bring with them a concept of chemistry gained through motion pictures, science stories and magazine articles, and from other people. This concept includes such ideas as those of making valuable chemical compounds, finding out what an important substance contains, and carrying out investigations leading to discoveries which he considers important. The pupils live in a world of plastics, cosmetics, soils, and dyes, where people cook, eat, produce goods, get married, get sick, make living things grow and preserve things—even human bodies. The planning and thinking activities of individuals, including children, are likely to be fruitful when they begin with familiar ideas and situations.

The teacher, with his greater experience, lives in a bigger world. He has discovered the value of certain "basic" principles of chemistry—tools for use in approaching new science situations—and he feels responsible for helping pupils learn these same principles, and quickly. Frequently, teachers appraise inadequately the importance of the process by which they arrive at their generalizations and feel that pupils can arrive at the teacher's level of comprehension through a shorter method—by listening to an account of the teacher's summarized knowledge or by reading such ac-

counts. This process results in confusion for most pupils. A few pupils, by substituting direct experience, learn in spite of the teacher.

In order to utilize the desire of the chemistry pupil to learn more directly how technological advances are related to recurring problems of living, the teacher's way of working, from the outset, must successfully enmesh principles of chemistry with a variety of significant problems of living. A teacher wishing to develop such a process must give considerable attention to the establishment of at least three related, yet distinct, continuities which govern the process and which are maintained through systematic evaluation. The discussion which follows is concerned with these continuities.

CONTINUITY IN GROUP EXPERIENCE

In classes of thirty or more pupils, the teacher must work more often with the group than with individuals. Yet the wide range of individual abilities and interests present in any classroom group demands considerable attention in order to insure continuous growth for all pupils rather than continuous elimination of pupils. How can the teacher operate in order to promote continuous group growth?

So far, provisions for a wide variety of learning activities representing different degrees of difficulty, yet closely related through real and important group objectives, seem to provide the most satisfactory approach to this problem. Many teachers have proceeded from a group of clearly defined values which they use continuously as points of reference in making decisions and in helping pupils decide what activities are valuable, why they are valuable, and how activities might best be carried out in order to realize the values desired. Such a list of values gives meaning and direction to group planning, group discussion, group cooperation on the solution of a problem, and group evaluation of group understandings. These values provide a basis for the establishment of one important kind of continuity.

A partial list of values for group work in chemistry includes growth in understanding the following:

(1) How to go about learning chemical language
(2) What is involved in reading chemistry materials
(3) What to consider in making predictions regarding chemical reactions
(4) How to test the acceptability of reasons used to support a conclusion
(5) How to plan an experiment in order to answer questions
(6) How to identify the social significance of science experiments, chemistry discoveries, and chemistry situations met daily
(7) How to record evidences of progress toward group goals
(8) How to go about making satisfactory group decisions

These values have been stated in terms of broad achievements to be sought by the teacher and the group. The actual plans made by those seeking the achievements should go far enough to indicate the steps and materials appropriate for the desired achievement.

Progress toward these achievements can be identified by systematic and continuous collection of evidences of progress from situations where the particular value is expected to operate. A few types of evidences are suggested for use by teacher and pupils in determining cooperatively progress toward the first four values mentioned above.

Learning chemical language

Increased use of appropriate chemical language in group discussions

The extent to which the group gets correct ideas from chemical language encountered in chemistry books and periodicals, motion pictures, advertisements, and chemistry tests

The extent to which members of the group are able to help each other get meaning from various language situations involving ideas and symbols of chemistry

Reading chemistry materials

A diagnostic summary of the reading of chemistry materials done by the class, including categories such as reference reading, stories

about chemistry, and social problems related to chemistry

Class records which show the extent to which the class uses or fails to use reading skills such as recognizing support or contradiction, and recognizing limits in the meanings of a passage

Predicting results of reactions

The extent to which the group turns to such bases as heat of formation, electrochemical series, solubility tables, valence, and periodic characteristics, in making predictions

Supporting conclusions

The extent to which the group requires its members to support conclusions expressed in reports, discussions, and group action

The extent to which the group recognizes and rejects unacceptable reasons offered in support of conclusions, such as false statements, false authority, irrelevant statements, and ridicule

Obviously, it is the teacher's responsibility to plan for the establishent and maintenance of this kind of continuity. The greatest justification for a teacher as leader of a class is that he, better than the pupils, understands clearly the values which the study of chemistry can promote. He must stimulate pupils to accept values because they understand them and have faith in them, and because they see clearly how to realize these values through work and study activities. This kind of understanding leads pupils to accept responsibilities for giving evidence of their growth in terms of the values.

CONTINUITY IN INDIVIDUAL EXPERIENCE

Continuity in individual experience is established and maintained through purposes for the individual pupil's work agreed on by teacher and pupil. From class plans, a student can obtain considerable help in understanding how to further his own growth in chemistry. However, the class plan is usually too general for the detailed tasks which the individual pupil faces. For example, one pupil may wish to prepare hydrogen and to use it in hydrogenating a quantity of peanut oil. Another pupil during a study of reactions may wish to prepare hydrogen for use in reducing an oxide. The class discussion might help both of these pupils understand possible ways for obtaining metals from compounds but each pupil will need to plan the details for carrying out his particular investigation.

As the pupil plans his investigation under the guidance of the teacher and as he carries out his plans, the teacher can suggest steps in planning which will yield those kinds of individual growth which the pupil needs and desires. A list of kinds of growths which might be promoted through individual activities includes the following:

Ability to get needed information from chemistry sources

Ability to communicate his own ideas to others in clear writing

Ability to make adequate plans for his investigations

Ability to manipulate chemical apparatus for various purposes

Ability to formulate generalizations which follow from data which he collects

Ability to use generalizations as a tool for problem solving

Ability to use number concepts needed to carry out his investigations

Ability to economize time and materials

Interest in reading chemistry books other than text books or reference books for broader view of chemistry

Ability to collect and organize information concerning the various phases of his growth

Accounts of the work of scientists, or other orderly investigators, reveal an effective general pattern of approach involving opportunities for individual growth. First, the investigator encounters a problem that is real and challenging to the extent that he wishes to explore it. Through the process of scientific analysis he arrives at certain tentative conclusions. Later, as he works on other problems involving similar elements, he finds the same factors operating and draws similar conclusions. Finally, after a series of experiences involving similar elements in a sufficiently wide range of situations, he can safely state a generalization or principle that seems to be true under specified conditions. A scientist does not learn principles in the abstract. He does not attack a generalization directly. Always, he begins with a specific problem which he feels is worthy of investigation.

Science teachers believe in this process; they may use it in their own explorations but they do not always allow or encourage their pupils to use it. Even infants and small children learn quickly and naturally through this process.

Again, a continuous and systematic plan for collecting and interpreting evidences of progress toward each goal is necessary, in order to discover goals requiring intensive pupil-teacher effort. Devices which teachers have found unusually valuable and economical in collecting information concerning the growth of individual pupils include (1) a pupil estimate of progress in the form of a check list on which the pupil indicates what he is trying to do, what he has done, difficulties which he faces, and materials which he has found helpful, and (2) a folder containing a growing collection of progressive samples or descriptions of pupil work and notes indicating ways in which each sample represents an improvement over the preceding sample.

CONTINUITY IN SUBJECT MATTER

The accumulated knowledge of chemistry should be used to further the growth and development of the learner in the direction of chemistry goals. These goals provide the only valid basis for the selection and organization of accumulated knowledge for use in a particular chemistry class. Obviously, a close relationship exists between subject-matter sequence and the continuities discussed previously.

The subject matter which characterized early science writings was selected with a view toward training the faculties—mental discipline. Indeed, the fact that certain knowledge was highly formalized and systematized and was exceedingly difficult for the learner was considered a point in its favor, on the ground that it contributed toward mental discipline. Though modern psychology has given experimental proof that the conception of mental discipline is inadequate, considerable science teaching is still not only congenial to this outmoded theory, but can be justified only in terms of it. [1, 2] The practice of requiring the memorization of fixed quotas of factual material, the haphazard assignment of problems and fixed lists of laboratory experiments, the attention to abstract reasoning—all unrelated to life situations—suggest that a belief in the faculty theory still persists.

In the field of chemistry, knowledge has accumulated rapidly—so rapidly that not all of it can be communicated to the learner through lectures and textbook summaries. Motion pictures and other teaching aids are being produced which give accounts of processes by which certain important knowledge came to be accepted as authoritative. Teachers are learning to use these teaching aids in addition to discussions as means of furthering the pupils' understanding, and are finding them undoubtedly more fruitful in terms of self-direction than mere intellectual grasp of subject-matter content.

In actual practice, continuity in subject matter, related to the purposes of chemistry, has been most difficult to establish. The systematic organization of subject matter in terms of certain classical problems and experiments in chemistry and the hypotheses growing out of a study of these problems (seldom related to the pupil's problems) has preoccupied many teachers to the extent that they have assumed the presence of continuity for pupil development toward desirable goals. In reality, the goals have remained isolated and there was merely systematic organization leading to the testing of other people's hypotheses.

Irrelevant materials are likely to be included in subject-matter sequences unless suitable criteria are set up and used by teacher and learners. The following criteria are offered as illustrations. Teachers should recognize the danger in applying only one or a few of a set of criteria instead of all criteria in the set.

(1) Is the material a necessary part of the scope implied in class or individual purposes?
(2) Is the information reliable?
(3) Is the material of immediate value to the learner in some undertaking?
(4) Is the information continuously usable by the learner?
(5) Does the material represent a necessary part of a broader concept in chemistry which the learner must understand in order to achieve a purpose which he has accepted?
(6) Does the material possess adequate interest content?
(7) Is the learner in position to get sufficient meaning from the material?

If one accepts the idea that subject matter serves as a means to some ends rather than an end in itself, his evaluation procedures must be directed toward finding the extent to which ends or goals are being approached. Indeed, factual information tests at the end of the course have no value in the establishment and maintenance of continuity in the growth of a pupil enrolled in a one year course in chemistry. The real question is: To what extent is the chemistry pupil or class acquiring and using subject matter to achieve the purposes which they have formulated? Evaluation data relevant to this question may be obtained from subject matter tests administered early enough to permit modification in individual or class plans to be made in terms of the results of such tests. The analysis of students' discussions and written work can yield valuable data on the kind and amount of factual information used by pupils and on the ways in which they use it in supporting conclusions, predicating causes or predicting effects, explaining situations, and planning investigations.

The three distinct kinds of continuity which have been identified and discussed seem to be important in furthering the growth of high school and, perhaps, college chemistry pupils.

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FOUR YEARS OF SCIENCE

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The purpose of this article is threefold. It is, first, to present a tentative course of study in outline for a continuous science experience in high school; second, to suggest a teaching plan which might serve such an experience; and third, to indicate some of the obstacles to the institution of such a science curriculum.

The tentativeness of these proposals is especially stressed. There is no assumption implied here that science teachers are convinced that four years of science are desirable. Even if it were true that the majority of teachers would support a plan for four years of science in high school, it would require a particular type of rashness to assume that there is any one way of presenting such science. It is to be hoped that any plan of science teaching will be the result of classroom experience and experiment. This is especially true of any plan for four years of science—and more so of any plan which attempts to cut across subject matter lines. The plan described here is offered in the thought that much can be gained from the early criticism of a course of study, for it can then be subjected more profitably to trial and experiment.

Why a continuous experience of four

years of science? In a world where science and technology have so profoundly affected life and living, it is necessary to have citizens who understand and appreciate the role of science in society so that science can continue to be a tool for improvement and cease to be a weapon for destruction; so that those who are not specialists in science will understand and cooperate with those who are; so that a practical knowledge of the methods of science can be used in practical solution of problems of living.

The tentative proposals presented here are not merely the result of fancy. Fusion in science courses has been tried. Witness the attempts of Bagby [1], Todd [2], Hausrath and Harms [3], Federer [4], Tenney [5], Peterson [6], and numerous others [7]. In the writer's own preliminary experimental work in two half-year courses and six one-month units, with classes of average scholastic ability, it appeared that a fusion course of science experiences, organized under the problems of living of the adolescent and adult world, was reasonable and practical as well as desirable.

In these trials, when respiration was studied, for instance, the structure and function of the respiratory organs were examined; alveolar structures were studied under the microscope; dissections were made; oxygen and nitrogen were prepared and their properties (in relation to respiration) were studied; and the principles affecting the behavior of gases were considered. In this very brief account of a minute division of science, it is clear that subject matter usually considered under general science, biology, chemistry, and physics was combined into one experience concerned with a life problem. Owing to various circumstances, the results of this brief experiment are not sufficiently valid to be acceptable data.

With regard to this type of science curriculum and other curricula, it is hoped that policy-making bodies will embark on a number of experimental studies designed to yield data as to the relative merit of existing as well as proposed courses of study. One of the most remarkable features of the history of science teaching is the science teacher's failure to apply the experimental technique, which he extols as one of the most valid operations in truth-seeking, to his own problems. Generally speaking, the climate of the laboratory appears to be lacking where science teachers gather to discuss problems of curriculum. Where is the evidence that any single science course now being taught has been evolved scientifically, under experimental conditions?

The history of the philosophy of science teaching runs roughly from the subject-centered, to the problem-centered, to the "needs"-centered, curriculum. Lately several policy-making groups have expressed themselves in various publications—for example, the Progressive Education Association in *Science in General Education* [8]—regarding the importance of emphasizing the needs of children in a democratic society. The philosophical connotation of the word "need" has been so much abused that we are forced to define it as it is used here. A need involves an interaction of a biologic (psychological, functional, or emotional) drive or goal motivating the child with the desires and goals of the society in which he lives. This is essentially the definition proposed in *Science in General Education.* Two factors determine a need—the child and the society in which he lives.

Now it is held by many teachers that the traditional subject matter of biology, chemistry, and physics is so organized because of convenience. Teachers are trained in these cubicles. They teach in these cubicles. Textbooks are written in these cubicles. And laboratories are built as biology, chemistry and physics laboratories.

Is it possible that the objectives of science can best be met by organizing its

problems, its materials of instruction, its teaching around problems of living or around needs of children rather than problems of subject matter? This question can be decided best—some would say only—in the laboratories of science education. A plan for such teaching, open to criticism and modification, may be set forth here. It is worth repeating that these suggestions are preliminary in a very real sense.

A COURSE OF STUDY *

The four years of science are arbitrarily titled *Science and the Individual, Science and the Family, Science and the Community,* and *Science and the World.* These titles are not merely names. Emphasis is not placed on subject matter, but subject matter is to be learned only as it serves the personal, socio-personal, socio-civic and socio-economic needs of the individual. The need of the individual to be a healthy functioning citizen involves biology and chemistry, as well as physics and also other fields. The need of the individual to be adequately housed is related to the biology, chemistry, and physics of sewage disposal; the biology of the effect of sunlight on growth and disease; the chemistry of construction materials; the physics of forces; moments; refrigeration and ventilation—to mention but a few aspects. In a science curriculum based upon a traditional course in chemistry, biology and physics, the teachers of any one of these regularly delay complete solution of any problem till another cubicle of science is entered. In fact, many of them console themselves by answering students' questions with the statement, " We can't take this up here, wait till you get to physics." Possibly the boy or girl never reaches physics.

If it is a requirement of our age that boys and girls must understand their environment, then teachers of science should fulfill their function of furnishing the continuous experiences necessary for the understanding of these problems. And in much the same way that a need is an interaction between the desires of the individual and the desires of the society in which he lives, so problems of living generally involve the interaction of an organism (a biological entity) with its physical and chemical environment. This is merely to emphasize that problems in our world are solved by individuals who can correlate or fuse different areas of experience. This activity, our reasoning leads us to believe, may be served best by similar experiences in the learning situation devised in school.

It is clear that the sequence to follow may be modified in the particular learning situation. As a matter of fact, one of the advantages of the organization is that subject matter is used only as it answers a desirable and necessary problem. It should be just as clear that a complete syllabus cannot be presented in an article of this scope—the topics in parenthesis are merely suggestive and should serve as a frame of reference.

Science in Life and Living

I. Science and the Individual

A. Problems of adequate nutrition (Kinds of food; nutrients; chemistry and physics of digestion and absorption; chemistry of oxidation; diets in relation to health; the consumer.)

B. The function and structure of the body (Biology, chemistry and physics of respiration; biology and chemistry of blood; physics and biology of blood pressure; vision and hearing; introductory physics of light and sound; chemical tests of urine and sweat; excretion; first aid.)

C. Prevention of Disease (Water-borne diseases; air-borne diseases; human carriers; infection and contagion; applied chemistry of antiseptics and chlorination; immunity, public health measures; sewage disposal.)

D. A person's behavior (Structure and function of the nervous system in relation to learning and to habit formation.)

* Thanks are due to Joseph Wohl of Bayside High School and Moses Davis of Boys High School of New York City, members of the Experimental Committee of the New York Federation of Science Teachers, Mervin E. Oakes, Chairman, for suggestions concerning the outline of the course of study. Responsibility for this plan, however, is the writer's.

E. Leisure activities (Photography; nature study; pets; tropical fish; growing plants; radio; engineering activities; airplane models and aviation,)

II. Science and the Family

A. Reproduction (Reproduction of common animals; individual or group conferences on human reproduction where classes are mixed, or class discussion in segregated classes; prenatal care.)

B. Heredity (Principles of heredity; environment and heredity; application to human being; marriage; the early environment of the infant.)

C. Safety in the home (Prevention of accidents; the medicine cabinet; review of first aid.)

D. The home chemist (Chemistry of cooking and cleaning; chemistry and physics of clothing.)

E. The home electrician (Understanding electrical appliances at home; practical experience.)

F. The home biologist (Maintenance of food to avoid spoiling; elements of nursing the sick person; growing plants; care of pets; care of young children.)

III. Science in the Community

A. Eugenic factors (Improvement of the individual as a community problem; feeblemindedness; birth rate and death rate; war as a destroyer of germplasm and productive citizens.)

B. Euthenic factors

1. *Personal services* (Recreation; medical services; education.)

2. *Improvement of food* (Chemistry and biology of photosynthesis; heredity and biologic production.)

3. *Improvement of soils* (Chemistry of soils; hydroponics; practical gardening; fertilizers; physics of erosion; biological organisms; agricultural practices.)

4. *Conservation of resources* (Coal, metals, minerals and mining practices; forest and lumbering practices.)

5. *Housing* (Chemistry of materials; physics of structure; heating, ventilating, humidifying, refrigeration; biologic factors.)

6. *Energy* (Chemical energy for muscles, including a fuller discussion of chemical changes in blood and muscle than usual; machines; fuels, water power, electricity; future of atomic power.)

7. *Communication* (Telephone, radio, radar, television; automobile, locomotive, airplane; fuller treatment of light, sound, and wave physics, electronics; chemistry and physics of the combustion engine; aviation physics.)

IV. Science and the World

A. Science and technology (Effect on world economy; employment, leisure, communication; interrelationship among people.)

B. Racial understanding (Evolution of man and human races; racial understanding; brief psychology of human relations.)

C. The life span (Birth rate and death rate; factors affecting productive life and health.)

Objectives

Experts in fashioning science curricula will ask where the objectives of this course are to be found. The objectives of this course are the same as those accepted by the most experts, stated in practically every preface to school science courses, and included in most philosophies of science teaching, for example, in the reports of the American Council of Science Teachers. [9, 10] The additional objectives emphasized in this suggested plan are to be found first in the attempt to fuse the materials of science about problems of living. Perhaps this fusion will catalyze the integration of the experiences and opportunities of reaction in the lives of boys and girls, an integration which they need to make before they can adjust to life's situations in a satisfactory manner. Possibly if courses in the separate sciences were revised to meet these life situations, the same purpose would be accomplished.

The second objective is the one which is concerned with the need for continuous science experience in a world in which science is playing an increasingly important role. Administrators who cannot appreciate the objectives of an academic chemistry, physics, or biology course can more readily appreciate the need for citizens to understand the problems underlying health, housing, consumer chemistry, resources, fuels, technology, communication systems, and race. It is not enough for a student to be exposed to general science and biology when he misses the aspects of chemistry and physics that he should understand to live a more ordered and meaningful life.

A SUGGESTED TEACHING PLAN

Those of us who have inherited the traditions of the Herbartian steps or the Morrison Unit are aware of the influence of these teaching plans in the pedagogical practice of teachers. Briggs and others [11] review the value of the Morrison and

other plans that have been called laboratory techniques of teaching.

There is an advantage in the use of a given teaching plan if its practice facilitates learning. If the same plan could also bring into sharper focus the methods of science, there might be an additional advantage. The arguments advanced for the so-called Morrison unit are too well known to warrant repetition here. The same reasons can very well be advanced for the type of plan to be suggested here; it will be referred to here as the " Science Unit." (Observation of different teachers shows that this plan is already in use at least for some lessons by many. It is possible that it has been mentioned in the literature, but this writer has failed to find appropriate source material.)

It may well be asked whether the addition of more terms to a bulging educational vocabulary, already replete with obfuscation, is necessary. It is felt that if the method helps serve the purposes of science, its inclusion here is justified. In certain categories its similarity to aspects of the Morrison Unit will be readily apparent. The resemblance of the stages of the plan to the blue print of the scientific method will be obvious.

The Science Unit

1. *Recognition of a problem.* Teacher and students in committee consider the problems of living as they arise in the learning situation provided. There is no need to emphasize here the variety of ways a problem may arise.

2. *Planning to solve the problem.* This involves joint planning by teacher and students. Careful planning is one of the characteristics of the scientific method so often neglected in actual teaching of scientific method. It requires reading of the literature (textbook, pamphlets, source materials), setting up a plan of work (experiment, speculation, gathering of data), scheduling and allotting work.

3. *Solving the problem.* This may involve laboratory work, field trips, library work, discussion, mathematical analysis, project work, and accurate recording.

4. *Reporting data.* This may result in planning further experiments or other work, or in a tentative conclusion or hypothesis.

5. *Conclusion and generalization.* On the basis of the data, principles are derived.

6. *Application to solution of individual or community problems.* The principles derived or data gathered are applied to living so that better living may result. Science and society are not divorced; they interact.

It is thought that if these steps in the scientific method are used by students as steps in learning science, a greater appreciation of scientific method as it applies to their own lives may result. This hypothesis, of course, also requires experimental investigation. Surely the Morrison Unit and similar plans, which were accepted as a plan of learning with very little experimental verification, should also undergo more complete investigation.

The Science Unit may be used—as it is in many cases—in a single lesson (as a lesson plan) or a unit projected over several days (as a unit lesson plan), but it may also encompass a few months' work on the problems of health, or national resources, or race (as a plan of a month or a term's work). The Science Unit may, therefore, be applied to the solution of a large problem or most of the subdivisions of that problem.

OBSTACLES TO THE INSTITUTION OF A CONTINUOUS FOUR YEAR SCIENCE EXPERIENCE

Several factors operate against the establishment of a continuous high school science experience. No attempt is made here to state them in order of importance.

1. *The specialized training of teachers.* Most teachers receive training in chemistry or biology or physics. Even though general science is not a fusion around problems of living, its institution faced the obstacles of the specialized training of teachers. Sometimes this training finds itself expressed in philosophies of formal discipline or just the common garden variety of the specialist's jealousy. If, however, the philosophy implied in a curriculum fused around problems of living is accepted, then teacher training institutions and in-service-training will, perhaps, fit the requirements of the philosophy.

2. Constants in the curriculum. Four years of science means that more science will be given to all students. In an already overcrowded curriculum, teachers of a subject endangered by the introduction of more science will oppose its introduction. The problem of what shall be taught depends on what objectives of education we accept. Even a casual examination of present writings in education indicates a growing concern about the manner in which education for life through education by living has been interpreted to mean so much English, so much foreign language, so much mathematics, so much specialized science, so many Carnegie units, and so many credits for college entrance. In *Education for All American Youth,* [12] the National Education Association has planted this seed of concern and it has blossomed into proposals for action which if widely adopted will change the structure of the high school curriculum so that it is related to the function of ministering to the needs of young people. In the " ten needs " of young people set forth in *Education for All American Youth,* two are concerned with science; these relate to the need for health and to the need for understanding science to understand the world.

There is no reason to assume that four years of science means four years of five periods per week of approximately fifty minutes each. There is increasing recognition that some modification of the Carnegie unit is desirable and that colleges need not dominate the high school curriculum. Furthermore, the idea of the community institute, junior college or advanced high school is finding increasing favor; this would provide for a lengthened period of schooling and for specialization after high school and before formal college training.

3. The lack of organization of science teachers. At present most science teachers are not in position to exchange ideas, to enter together upon revision, modification, or planning of curricula. In the past year or so, however, there is an indication that this may be corrected through the National Association of Science Teachers.

4. The failure of science teachers to apply the scientific method to problems of science teaching. One would think that teachers of science would hasten to apply the method of science to teaching. They have been trained in it; they attempt to train young people in its use; they extol it as *the* objective of any type of science teaching. But it may be said, in general, that the experimental method is not applied to elaboration of curricula and finds wide neglect in writings on science education. For instance, there is little evidence that any science course has been the result of experimentation, that is experimentation in its scientific connotation. There is little scientific work on the conduct and nature of a lesson so that supervisors in science can base their recommendations on the evidence. Even so, some supervisors in science have fixed notions on the nature and place of motivation, on the kind and statement of aim, on the place and kind of assignment. As a case in point, it is always edifying to ask a supervisor who has just criticized a lesson as " good " or " bad " for the scientific basis of his judgment. It seems clear that much would be gained if the scientific method were used more extensively to investigate the problems of the science teacher and, for that matter, those of any teacher.

The statement that teaching is an art is particularly without meaning. If it is, scientific investigation may yield little or nothing; but at least it can tell us that teaching in the classroom is not susceptible to scientific investigation and improvement thereby. Certainly those of us who have faith in the scientific method should apply it in an effort to learn the nature of teaching method. Perhaps we can learn whether " teaching is an art " or whether " teaching is a science " or whether it is both.

There is great need for a reconsideration

of plans and curricula of science teaching. There is great need to plan and conduct a series of investigations on methods of teaching in science and on the organization of curricula and courses of study. There is great need to foster the climate of the science laboratory in the areas of science education. As a matter of fact, it is planned to conduct an experiment at the Forest Hills High School in New York City, which will involve offering four years of field science in line with the broad outlines described here, and with suitable experimental controls of four years of specialized science courses. Toward this end, it is hoped that suggestions from interested teachers will be forthcoming.

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THE MEANING OF APPRECIATION

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APPRECIATIONS rank high among the objectives of general education and among the objectives of science teaching. However, the writer believes that too little is done by teachers in general and by science teachers in particular toward teaching for appreciation. This condition may result, in part, at least, from the absence of an acceptable common understanding of the term.

Before the science teacher can teach for scientific thinking, he must first know just what the term implies, and must use certain acceptable techniques. Even then he cannot guarantee that scientific thinking will result on the part of his students. In a like sense, the teacher must begin with some concept of appreciation and of how it might be developed. He cannot profitably teach blindly for appreciations, merely hoping that they will result. In this article an attempt is made to arrive at a suitable definition of the term *appreciation* by a careful analysis of writings on the subject. Of the many sources examined, the dictionary is the only one that attempts a formal

definition. All other sources studied, including books in the fields of psychology, philosophy and education, various magazine articles, and course outlines, merely discourse upon the subject. No one seems to know exactly all that "appreciation" implies. For the most part, however, all sources studied agree on some elements involved in the term. In the definition formulated these elements have been incorporated. There is by no means any claim that this definition is absolute.

DEFINITIONS AND DISCUSSIONS OF "APPRECIATION"

Funk and Wagnall's *New Standard Dictionary of the English Language* defines the term *appreciate* as follows:

(1) To be fully aware of or alive to the value, importance, or worth of; esteem adequately or highly; see the full import of.
(2) To be keenly sensible of or sensitive to; have the power of sharply discriminating in reference to; adequately perceive or distinguish.

The same source then defines *appreciation* thus:

(1) The act of appreciating; true or adequate apprehension or estimation, as of qualities, merit, or value; sympathetic recognition of excellence; as *appreciation* of home.
"All true *appreciation* is the result of keen insight and noble passion." Blackel, *Self-Culture,* p. 93 (c. 1874).
(2) Susceptibility of sensitiveness to delicate distinctions; keen perception as to points not obvious; as *appreciation* of minute differences in length.

In considering the development of appreciation through education, Broening [1] points out that appreciation is "the reaction of what we are to what presents itself for our approval, enjoyment, and possible inspiration . . . Study may be necessary preparation for appreciation but does not constitute appreciation." She further defines appreciation as

. . . emotionalized insight: an idea with a glow, an understanding with sympathy, a laugh with a cause; a sob with sincerity. Appreciation is a complex of several sorts of enjoyment:
(1) Intellectual: i.e., pleasure through exercise of mental activity for its own sake; or through weighing evidence of it.
(2) Physical: joy of the out of-doors; pleasures in physical exercise.
(3) Technical: appreciation of the skill involved in good workmanship.
(4) Humorous: appreciation of farcical and incongruous situations; also the wit of intellectual peers.
(5) Social: appreciation of human motives, desires, and of the pleasure of shared activity.
(6) Aesthetic: pleasure in contemplating or creating the artistically beautiful.
(7) Ethical: the appreciation of right and wrong.

In the *Dictionary of Philosophy and Psychology,* [2] Baldwin defines appreciation as "a way of formulating the distinction between judgments involving value and those of science, which latter pertain to fact." (Vol. I, p. 62). The suggestion is then made that the reader study the meaning of "worth." Baldwin defines "worth" as:

A determination which involves any sort of subjective appreciation; equivalent to value. It will appear from this definition that worth is, in all its forms—hedonic, utilitarian, economic, aesthetic, ethical, social—(a) a function of conation; there is no worth but satisfies or stimulates, or embodies some impulse; and (b) relative to some sort of subject. (Vol. II, pp. 822–823).

"Worth," therefore, "defines an attribute neither of subject nor of object, but rather a functional relation between the two. All values are therefore descriptive of such actual or possible relations." (Vol. II, p. 823). Further reading convinces one that the feeling still held by many persons that appreciation applies only to emotional reaction may be traced back to the philosophies of Kant, Herbart, and Lotze, and that modern popular usage suggests both emotional (abstract) and practical utilities as constituting the sphere of appreciation.

In the use of the term *appreciation* in connection with types of teaching, it would appear that Morrison thinks of it as being purely emotional, as dealing "with those adaptations which are felt." [3]

In a little volume by Lorado Taft entitled *The Appreciation of Sculpture,* [4] the preface under the name of the American Library Association contains the following statements:

> This course has been prepared for men and women who wish to be better equipped to enjoy sculpture. If you desire to increase your knowledge in other fields, you are referred to the other courses in this *Reading With a Purpose Series* and to your Public Library.

We can see from this quotation that both enjoyment and knowledge are considered aspects of appreciation. In the body of the same volume, Taft in referring to kinds of sculpture says, "Fortunately, however, it is no more necessary to limit your enjoyment to any one of these expressions than it is obligatory to eat a single kind of food or to enjoy but one species of flower." (P. 22). Further on he states, "A potent factor in appreciation is a conviction or principle, by means of which all works of art are unceasingly measured." (Pp. 22–23). It is apparent that Taft regards enjoyment and a sort of recognition of merit as factors in appreciation.

PHASES OF THE PROCESS OF APPRECIATION

According to Hall-Quest * the process of appreciating may be analyzed into the following phases:

- Cognition or the understanding of meanings
- Imagination or the reconstruction of experience; creativeness (interpretation)
- Emotion or the climate of appreciation
- Conation or the maturing of taste
- Expression or creative living

Cognition

The first basic factor in appreciation is cognition or understanding. The teacher's function is to make it possible for the learner to see what he was intended to see. Before one can appreciate anything, he must know something about that thing. Emotion is a factor but not the basic factor of appreciation. One must understand or have knowledge of the thing.

If appreciation is to be the aim, we must teach the meaning and purpose of science. Science gives us grounded knowledge. It should be so taught as to assist the student in adjustments to nature, society, and religion.

Imagination

The second factor in appreciation is imagination. Imagining involves a reconstruction—the bringing of images before us in order that we may reorganize them into something worthwhile, something creative. Creativeness involves a store of images. Imagination takes all experiences, whatever their source, and constructs ideas and concepts which become instruments for interpreting the immediate. Our scientific training should give us an insight into relationships.

Concerning imagination Beard says,

> Imagination is the correct word. Science and engineering do not reject it and substitute mere logarithmic tables or routine mechanical procedure . . . Without it, science and engineering become dogmatic and sterile. It must be and is being cultivated and nourished as one of the essential forces of the modern world. Imagination, informed by the known laws of nature, but unbound and free to experiment and dare, combined with the spirit of rationality, lives and flowers in the engineering age and will swing new planets into the ken of those who watch the heavens for signs of the future. [5]

Emotion

Emotion is the third factor in appreciation. There is the feeling among many individuals that appreciation connotes a sort of running wild of the emotions. It cannot be too strongly emphasized here that emotions are controllable and that appreciation teaches their control.

Emotion is associated with certain secretions of the ductless or endocrine glands. Emotion is experienced by us in the form

* Professor Alfred Hall-Quest develops this analysis in a course in the Division of General Education at New York University. The elaborations which follow are based largely on notes taken in that course, "The Place of Appreciation in Public Education."

of certain circulatory changes, and we refer to these phenomena as love, hate, fear, and the like. Emotion accompanies or follows an act but does not come before the act. According to Prescott, [6] emotions are classified as mild, strong, and disintegrative. The desirability of mild emotions is stated by Prescott in the following words:

> Mild excitement is sought by most people and these researches give ample justification for maintaining that its effects are physically desirable rather than undesirable. This supports the practice of accompanying meals with soft music, attractive decorations, and gay conversations; it perhaps explains the sense of physical well-being that accompanies dancing, participation in games, the attendance at recreational spectacles, the experiencing of beautiful landscapes or seascapes, the moderate excitement that accompanies any aesthetic experience, and the initial stages of love-making. (Pp. 20–21).

Conation

The fourth factor in appreciation is conation or the maturing of taste. A progressive liking or development of taste should be an outcome of education. Love of beauty, growing respect for proof, cautious judgment, open-mindedness, tolerance, and accuracy should all be educational outcomes. With long exposure, it is hoped, these will come. Taste is one's general attitude toward things of beauty, standards of behavior and the like. A child does not have taste. When, however, he is exposed to the best in art, literature, music, and the like, he can develop desirable tastes and thus gradually acquire one of the basic aspects of appreciation.

Expression

The final factor in appreciation is expression. Since the human individual demands expression, education should provide the "avenues." In this age of mass production the educators should, if they desire to develop ability of expression in children, call more attention to crafts, music, art, literature and other media, not for commercial reasons, but for the sake of expression. All forms of creativeness should be discovered and developed. Concerning expression Prescott [6] says:

> A very fertile field awaits the student of the effects of aesthetic experiences upon the establishment of attitudes and of patterns of emotional behavior. To date, little research has been completed, but we do know that music, dancing, nature experiences, motion pictures, museums, dramatic presentations, and various expressional activities play a part in the moulding of value concepts, attitudes, and patterns of affective behavior. The use of aesthetic media to establish emotionalized values or beliefs about political, economic, and social matters is highly significant for educational practice—witness the rise of the "new art" in all of its forms in Russia. (P. 90).

Cognition, imagination, emotion, conation, and expression, the five phases of appreciation here analyzed, should be kept in mind when appreciation is the ultimate goal of teaching.

TEACHING FOR APPRECIATION

In discussing the nature of appreciation and how appreciation may be taught, Struck says:

> Appreciation is largely an emotional response. It is not without elements of knowledge. Knowledge often deepens and enriches appreciation. But individuals can have intelligence without possessing a normal ability to appreciate. . . . Appreciation develops best through feelings of freedom, happiness, and interest. Appreciation does not come through unwelcome drill but through pleasurable learning experience. [7]

It is interesting as well as enlightening to see what a teacher of the most "scientific" of all the sciences, physics, has to say about appreciation. James P. Davis, in discussing methods for the improvement of instruction in physics, says:

> There is very little literature on lessons in appreciation and there are no references in the field of psychology. The major handicap to the development of appreciation in our schools is found in the limited view of appreciation. Appreciation is thought by many to be limited to the fine arts, and limited to an emotional experience. Most of the teaching has been directed to having pupils like something.
>
> I believe real appreciation is essentially an intellectual rather than an emotional experience. If it is an intellectual experience, then appreciation begins with understanding, and without understanding there can be no appreciation.

> My plea is to stop saying we are teaching appreciation until we have taught basic principles. Let us teach the pupil to understand the fundamental concepts of physics, to think scientifically, and then by teaching evaluation we can have the student learn to appreciate. [8]

As a result of the discussions of appreciation by eminent psychologists and educators and the analysis of aspects of appreciation by the writer, the following definition of the term is offered:

Appreciation, which involves both intellectual and emotional elements, is a sensitive awareness to and perception of the importance or utility of information in its relation to other fields and in the development of attitudes and tastes.

It may be noted that no reference is made to action or expression. If appreciation is developed, expression in some form is likely to result. This expression is not necessarily overt but becomes so as appreciation is intensified. Although, in the writer's opinion, expression is not a part of appreciation, it is a desirable reaction to appreciation. In the teaching process opportunities for expression should be amply provided.

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Aspects of Our Present Culture. *There is likely to be little disagreement with the statement that our culture is witnessing one of the most rapid developments and changes in the history of Western civilization. There can be no quarrel with the proposition that science—invention and technology—has been largely responsible for this unprecedented growth. . . . The change has been so rapid that we have not yet developed a terminology suitable for discussing with facility the new order of things. The science responsible for alteration of culture patterns has operated on the plane of invention—a mechanistic science, for the most part, worked out in discrete areas of biological and physical discovery, without adequate recognition of responsibility for its social and economic effects. . . . Understanding of the environment is not so simple a matter as it may once have seemed; the development of a technological society has made the conditions under which we live progressively more complex.*—"The Education of the Science Teacher." A Report of the National Committee on Science Teaching.

EDUCATIONAL TRENDS

EDUCATIONAL POLICY AND THE SCIENCE TEACHER

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The past few months have seen the publication of two major documents on educational policy which will have far-reaching influence in American secondary schools. Both are published by the National Education Association: one is distributed by the National Association of Secondary-School Principals; the other by the Educational Policies Commission. The fact that one of these documents, *Planning for American Youth* [1], is a 63-page summary of the other, *Education for All American Youth* [2], still permits us to report the publication of two basic documents rather than one, for the summary report is so graphically portrayed, so cogent, and so readable that it stands as a major report in its own right. Without doubt it will go far in influencing curriculum as well as administrative changes in American schools, for it is issued by responsible and representative groups and is distributed to every secondary-school principal in the United States as well as to other educators.

These reports strike no novel note; rather they draw upon and reflect the recommendations of various organizations of teachers and administrators over the past two years. However, the educational program they suggest for secondary schools will—where adopted—result in a markedly different offering to young people and will necessitate quite different teaching procedures and organization of subject matter than have been common in America. If it were not for the procedures suggested by which the recommended changes could be effected, it would be no overstatement to indicate that the reports call for drastic changes in educational programs. But such procedures are suggested and they allow for planned, careful growth in which teachers play a full part in modifying their curricula in the directions indicated.

It may be stated confidently that science teachers and their work will be affected by community responses to these reports. Some will be affected more and sooner than others, for local administrators will vary in the alacrity with which they accept and attempt to modify their programs to conform with the recommendations of the reports. But over a period of years science teaching will be influenced by these recommendations in ways that depend partly upon science teachers' reactions to them. The choice is to understand the recommendations, to help in shaping local policy, and to exercise leadership in regard to their own work on the one hand, or, on the other, to ignore the recommendations and to find their place in education being changed by this default.

FUNDAMENTAL ASSUMPTIONS

Certain assumptions underlie the recommendations made. They are as follows:

1. Education can and must be planned to meet the needs and interests of *all* youth. It is known that 44 per cent of the youth who now enter high school never complete it. Many leave school because it seems to provide little of worth to them in terms of their interests, aptitudes, needs, and goals. Many others leave school for financial reasons.

2. Individual differences—in sex, group affiliations, home and social backgrounds and status, emotional and physical health, intelligence and aptitudes, recreational and

vocational interests—require differences in detail of educational programs.

3. All youth have certain broad educational needs in common: to develop salable skills; to develop and maintain good health and physical fitness; to understand the rights and duties of the citizens of a democratic society; to understand the significance of the family for the individual and for society; to understand the influence of science on human life; to know how to purchase and use goods and services intelligently; to develop appreciation of literature, art, music, and nature; to be able to use leisure time well and to budget time wisely; to develop respect for other persons; and to grow in ability to think rationally.

4. It is the job of the school to meet the common needs of youth and the specific needs of individual youth.

5. The social and individual needs of youth can be met only if all youth remain in school until graduation from high school (after twelve years of schooling) or until reaching the age of eighteen—this regardless of race, national heritage, economic ability, sex, or social status.

The Schools' Provision for the Needs of Youth

How have American schools provided for the needs of youth? Some schools have provided an elective system of separate courses among which students may choose as they please. Such schools are much like cafeterias in the range of their offerings and the freedom with which young people can select. The argument against such freedom of offerings rests on the assumption that young people are too immature to select wisely in terms of their needs.

Other schools have established curricula with little or no choice offered. Such schools are like small restaurants in which young people take the menu provided regardless of individual needs and interests. The chief argument against such inflexible programs is that they are historically based upon college preparatory functions and consequently are poorly adapted to the needs of the majority of secondary school youth.

Still other schools offer basic courses organized on personal and social needs of youth and required of all. These courses are augmented by a variety of other courses from which the student may choose to meet his individual needs and interests. The analogy is drawn between such offerings and those of large hotels which provide basic menus with various side dishes of choice.

The reports state emphatically that the curriculum pattern of these latter schools is better adapted to the full discharge of the school's responsibility to young people than those of the other two. The recommendations made assume such a general pattern and particularize it in illustrative programs drawn up tentatively in terms of the needs of rural and of urban youth. The administrative organization used for the purpose of the sample programs is one which allows for an eight-year secondary school, from grades 7 to 14.

An example of such a program that might be offered to the youth of an American "Farmville" is organized in three curriculum areas. The time alloted to each area would vary, but in general 400 hours would be given to the first each year, 300 hours to the second, and 500 hours to the third. The curriculum areas are:

1. *Developing as a citizen*
A developmental consideration of such matters as consumer education; the organic, inorganic, and social world; scientific method, expression, and quantitative relationships; American backgrounds and culture; principles and practice of school, local, and national government; peoples, agencies, and industries providing goods and services to the people of a community.
2. *Building health and physical strength*
Physical and emotional changes of the organism during adolescence; sex instruction; relations with the opposite sex; health habits of cleanliness; food, body care, dis-

ease; games and sportsmanship; development of physical strength.

3. *Exploring personal interests and abilities*
   Analysis of interests and aptitudes; acquaintance with languages, sports, crafts, music, art, and with wide areas of interests and activities.

Where is science to be taught in such a program? Science subjects, English, mathematics, and other usual disciplines of the traditional curriculum are taught in all three areas in an integral fashion as of how an educational program might be planned. Fig. 2 is an illustration of the manner in which young people might proceed through grades 7 to 14 with five major curriculum areas.

It will be noted that a single period per day is provided on every grade level for the purposes of health instruction and physical fitness activities. The exploration of personal aptitudes and interests in various areas which is allowed two periods per day

FIG. 1. Recommended Curriculum for Rural Secondary Schools

CURRICULUM AREAS	NUMBER OF HOURS ALLOTTED IN GRADE 10	11	12	13	14
1. *Preparing for an occupation*	*200*	*300*	*400*	*600*	*600*
Job analysis, personal analysis, and job preparation for agricultural, mechanical, commercial, and home-making fields of work. *Work in science, mathematics, and other special subjects as such when preparatory to advanced study in college.* (Presumably courses in physics and chemistry would remain much as they now are but would be taken by college-preparatory students and as electives by all interested. See 3, below.)					
2. *Developing civic competence*	*300*	*250*	*200*	*200*	*200*
Civic projects, consumer education, current political and social problems, historical development of democracy.					
3. *Developing personal interests and aptitudes*	*550*	*500*	*500*	*200*	*200*
Family life, health, mental hygiene; physical education and recreation; cultural heritage of music, art, literature, science, etc.					
Elective studies in science, mathematics, languages, and other subjects	*150*	*150*	*100*	*200*	*200*

they can make their specific contributions. Separate courses in science do not appear.

Three curriculum areas are also basic to the last five years of "Farmville's" secondary-school program. These differ somewhat from those of the first two years. Again the amount of time to be devoted to each area is suggestive only. The areas and the time allotments are shown in Fig. 1.

Where is science to be taught in these grades? As an integral part of the second curriculum area and as separate courses for those electing such work in terms of interest and because of college work expectations.

The curriculum of "American City" is not dissimilar to that of "Farmville." The same basic goal of meeting the "imperative needs" of youth produces another example during the first three years of the secondary school is continued in some cases during later years as a one-period study under guidance. More commonly a student would be given an increasing number of periods for vocational preparation, including, when appropriate, study in college-preparatory sciences.

A "common learnings" or "core" course is the most noteworthy course in the curriculum. This course is to embody content and experiences believed to be of fundamental importance for all youth. Three periods a day are allowed for this during the first three years of secondary school; two periods during the eleventh and twelfth years, and one period for each of the years following which comprise an extension of the secondary school into the "junior college" two-year program.

FIG. 2. Time Allotments for Recommended Secondary School Curriculum

Periods per day	Grades 7 8 9	10	11 12	13 14
1.	Personal interests. Exploration of personal aptitudes and interests in science, art, music, sports, crafts, etc.	Individual interests. Election by the student under guidance.		
2.		Vocational preparation. Study of science, mathematics, and other subjects for college preparation. Job preparation for commercial, mechanical, and home-making fields.		
3.	Common learnings. "A continuous course in social living to foster growth in personal living and in civic competence. Guidance of individual students is a chief responsibility of these teachers."			
4.				
5.				
6.	Health and physical fitness. Study of individual and community health. Games, sports, and similar activities.			

THE PLACE OF SCIENCE

What will be the place of science in the schools of the nation if some such programs as those of "Farmville" and "American City" are developed generally? Science will remain as an elective subject for those who desire to take it for its intellectual challenge, its personal interest and social worth, and for reasons of college entrance and preparation. The popularity of such elective courses as physics, chemistry, biology, and perhaps such offerings as botany, astronomy, geology, photography, radio, and electricity will depend rather largely on what curriculum modifications are made in the years to come. The pattern is changing considerably and newer textbooks and courses of study reflect an experimental temper designed to discover in science offerings that which is of the greatest value to young people and society.

But the amount of time allotted to elective subjects is restricted in such programs as these. If the only contribution of science to the education of the young is to be in such special—and really restricted—courses, the importance of science education will diminish appreciably.

Such is not the intent of the authors of these reports. On the contrary, it is because of their recognition of the permeating and pervasive influences of science on all aspects of living that they recommend a close articulation of science with such other disciplines as social sciences, English, and mathematics in a focused attack on the basic needs of youth and society. There is, in other words, a strong conviction that the fields of biological and physical science have contributions to the education of youth which are of such fundamental importance that *all* youth should profit from them.

These contributions are believed to be made far better if the fields of science are searched for them in terms of the imperative needs of all youth rather than in terms of an internally developed sequence of factual learning in science. This reflects the position which has increasingly been taken by science teachers and their organizations over the past decade. Recent pronouncements and reports of the National Committee on Science Teaching, the American Council of Science Teachers, and the newly formed National Science Teachers Association all reflect this trend of considering the criteria for selection and organization of content and experiences in science education to be the needs and interests of youth and society.

ARE THE PROGRAMS FEASIBLE?

The largest question that the science teacher will ask concerning the reports under review is in regard to the feasibility of the unified or common learnings type of courses. The scientist attempts to be a consistent pragmatist. As such he is forced to draw attention to the lack of success so common when "core courses" and other plans of unifying learning have been attempted. He may agree that science education for today's youth should be functional in meeting the needs of young people. But he may feel that it is a *non sequitur* to assume that it is necessary to establish unified courses to get this job done. He knows how vast are his fields alone and he questions how any teacher can become so thoroughly informed as to know sufficiently well the significant fields of science and of other disciplines in addition.

The reports suggest several possible solutions for this difficulty. One is for experts in science and other fields each to contribute a major share to the teaching of a common class which is under the continuing direction of one "common learnings" teacher.

There are sound objections to this and other possible arrangements. Basically the objections recognize that the training of teachers has stressed subject divisions and has been narrow in its specialization. The reports recognize this fact in these words:

> They [members of a Board of Education of a typical American city] knew their teachers for the most part had been trained to teach organized subject fields, and that the schools of American City had made little demand upon them for group teaching, for cutting across subject lines as was necessary in the courses in Common Learnings, and for cooperative planning for the total school program.

Therefore, according to the reports, the boards of education and county administrations should provide opportunities for all teachers to participate in the planning, reorganizing, and execution of the school programs. This means that the science teacher should expect to have a part to play in any changes made and should expect to learn from his cooperation with experts in other fields. Secondly a central staff of competent, professionally trained specialists should be employed to assist all teachers in learning and working out new procedures and materials. Finally a staff of curriculum workers should be available to search for new teaching materials and to aid in the organization of such material for classroom use. It is emphasized that the classroom teacher will be responsible for decisions as to what is taught in the classroom.

The actual programs of communities may vary widely and still follow the recommendations of the reports. These may be summarized in the statement that the needs of youth and society can and must form the basis for secondary education. Science is to find its place in educational programs as it sharpens its contributions to any or all of the imperative needs of youth.

Three possible responses may be forthcoming from the science-trained teacher. He may take leadership in implementing these recommendations through curriculum modification in science. He may take leadership in opposing the recommendations made because he believes them to be unsound or impracticable. Or he may ignore these reports and drift by default of attention into whatever programs his community may develop in the future. The reaction of indifference will clearly be fatal to sound science teaching if it is general among science teachers of the nation. These pages are available for a synthesis of the reactions of any science teacher, administrator, or educator who cares to speak either for or against the recommendations of these reports.

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RESEARCH DEPARTMENT

A CHRONOLOGICAL SURVEY OF RESEARCH STUDIES ON PRINCIPLES AS OBJECTIVES OF INSTRUCTION IN SCIENCE

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The true test of any course in science is the extent to which the understandings developed by the learning experiences of the course are able to bring about permanent and desirable modifications in the behavior of those who study it. The basic understandings of courses in science in terms of which behavior can be modified are to be found in the important generalizations and principles of science.

There are three chief centers at which research planned to clarify the concept of a scientific principle and to refine the statements of the principles has been carried on independently: the University of Chicago, Columbia University, and the University of Michigan. This research has been under the direction of Elliot R. Downing, S. Ralph Powers and Gerald S. Craig, and Francis D. Curtis, respectively.

Several studies on various phases of this problem are especially deserving of brief summarization because of the influence they have exerted on instruction in science.

In 1927, under the direction of Powers at Columbia University, a noteworthy pioneer study in this area was made by Craig [1]. An analysis was made of textbooks and courses of study in science, and of articles and discussions on the objectives of science in the elementary schools, to determine a tentative list of objectives from which to organize the course. A list of 45 main objectives was secured from these sources. Some of these objectives were stated as principles of science, which conformed to one of the three criteria set up, namely that "Certain objectives that are selected for elementary-school science should conform to those facts, principles, generalizations, and hypotheses of science which are essential to the interpretation of the natural phenomena which commonly challenge children." Examples of some of these objectives are "Matter and energy cannot be created or destroyed" and "All life evolved from very simple forms."

In 1927 Menzies [2], under the direction of Downing at the University of Chicago, made an investigation to determine the percentage of word space devoted by college textbooks of biology "to various generalizations, and to the application of these generalizations to practical life situations." Ten college textbooks of biology were analyzed. Forty-one important biological generalizations were found, to each of which the authors devoted more than five thousand words.

In this study no attempt was made to define a generalization, and those generalizations used for the evaluation of the materials in the textbooks were stated arbitrarily by the investigator. However, a considerable number of these principles conform, both in meaning and in scope, to the criteria employed in later studies for the determination of scientific principles.

In 1928 Heineman published a summary of a master's thesis [3], which was completed in 1927 under the direction of Downing. The study was concerned with an analysis of twenty textbooks of general science, published between 1915 and 1927,

to discover, first, to what extent textbooks of general science were "devoted to elucidation of scientific principles, and second, to what extent these principles find expression in the books in applications to life situations."

In this study a principle was defined as a generalization, "a statement of relationship, frequently causal in nature, between two facts," as distinguished from a "generalized fact" such as "all insects have six legs." "The principle, or generalization, is built on the basis of general facts, but, once molded, it serves to make meaningful other facts and conditions." A determination was made for each of the textbooks of (1) the number of pages devoted to principles, (2) the percentage of printed matter on principles, (3) the percentage of pages devoted to principles. Ninety-three principles were found in the textbooks analyzed. Significant conclusions of the investigator were that "principles were not uppermost in the minds [of the authors] when the books were written," and that "there was little unanimity among authors as to which scientific principles are of greatest importance at the general-science levels in the schools."

In 1929 Downing [4] published a synthesis of the results of four unpublished masters' theses which had been completed under his direction at the University of Chicago. Two of these studies, one by Watson (1928) and one by Widner (1928) were undertaken to determine the principles of physics appearing in farm journals; one, an analysis by Harris (1927), to discover the principles of physics found in trade journals, and one by Coon (1927) to find, by means of a "job analysis of the activities of the housewife, what principles of science she needs and to what problematic situations these apply."

Thirty-two principles of physics appeared in at least two of the four lists of principles secured, and in three of the studies the relative importance of each principle was found in terms of the amount of word space devoted to discussion of the principle or of its application to concrete situations. This published report contains no definition of a scientific principle and no statement of criteria by which to decide whether a given statement is, or is not, a principle.

In 1930, Sites [5], also under the direction of Downing, made a study to determine "what chemical principles, concepts, and technical terms are used in science magazines, . . . which are probably needed to enable the individual to read such magazines intelligently." For purposes of this study, a principle was defined as "a statement of a relationship which is significant in its application." A total of forty-eight principles of chemistry was secured by this investigation.

In 1931, Wilber [6], under the direction of Curtis at the University of Michigan, made an investigation to determine the scientific principles contained in textbooks of general science published between 1924 and 1931. In this study the criteria for the determination of a principle were formulated by six graduate students in a Seminar in Problems in the Teaching of Science.

The definition of a principle and the criteria for determining whether a statement was or was not a principle were stated as follows:

A principle of science is a comprehensive generalization which:

- Is stated positively and definitely
- Is true with but rare exceptions within the limitations set up by the statement
- Clearly states or implies a dynamic process or interaction
- Is demonstrable experimentally
- Is clearly not a part of a larger principle which can be definitely stated
- Is not merely a definition or a description
- Has wide application in the natural environment and is not ruled out by any of the preceding criteria

An analysis was made of fourteen textbooks in general science used in the ninth

grade and all statements which satisfied the criteria were selected. The principles were tabulated and submitted to subject-matter specialists in biology, chemistry, geology, and physics for validation in terms of the criteria and for revision of the statements which were inaccurately or unsatisfactorily stated. The list of 170 principles was then submitted to ten teachers of general science who were asked to designate those principles which were *necessary, desirable,* or *undesirable* in a general science course.

The findings were that "of the 170 different principles of science from all 14 textbooks, but 18, were given, even in part, in principle form, in more than half of the textbooks analyzed . . ., of these 18 principles only 5 were among the principles . . . which were regarded as *necessary* by the ten instructors who evaluated them," while five principles regarded as necessary by all the instructors were included in fewer than four of the fourteen textbooks analyzed.

In 1932 Downing [7] published a synthesis of the results of four unpublished studies made under his direction, which were concerned with a determination of the biological principles that appeared in the articles of a weekly magazine, in scientific books written for the lay reader, and in government bulletins. The twenty-eight principles secured from the studies were organized into nine main principles under each of which were put the related, but subordinate principles; the main principles were then arranged in the descending order of their importance, determined from the average rating of the several parts as indicated "in the available objective evidence."

In the published report of these studies, Downing gives no definition of a principle, or of criteria used for the determination of the principles. Several of the principles, however, conform to the criteria set up in later studies for the determination of scientific principles.

In 1934, an investigation was made by Bentley [8], under the direction of Curtis, "to determine those biological principles, a knowledge of which is most frequently needed for an understanding of articles appearing in the public press." In this study "no attempt was made to define a principle," but instead, Downing's list of biological principles was used as a basis for the study.

An analysis was made of one month's issues of five representative newspapers "to select those articles for which a knowledge of biological principles was necessary in order to understand their content clearly." A total of 1,111 articles in 180 issues of the papers "were of such a nature that an understanding of biological principles was necessary for an understanding of the article." Of the thirty-four principles in the list there were only five which did not appear at least once in the newspapers.

In 1934 Robertson [9], under the direction of Curtis, made an investigation to determine the important principles of science suitable to serve as goals of instruction in the elementary grades of the public schools. In this investigation, ten previously completed studies were used as sources for the development of a comprehensive list of major and minor principles of science.

The following criteria of a principle were established as a result of many weeks of careful consideration by a group of teachers of science enrolled in a Seminar in the Teaching of Science at the University of Michigan.

To be a principle a statement must be a comprehensive generalization.

It must be true without exception within the limitations specifically stated.

It must be a clear statement of a process or an interaction.

It must be capable of illustration so as to gain conviction.

It must not be a part of a larger principle.

It must not be a definition.

It must not deal with a specific substance or variety or with a limited group of substances or species.

The principles included in each of the sources were compared one by one with the criteria by a jury of three specialists in the teaching of science. The statements which, in the unanimous opinion of the jury, satisfied all of the criteria were retained in the list. The list of principles was further refined by a jury of subject-matter specialists who evaluated each principle for conformance with the criteria and for correctness of statement as a principle. The final list of 243 principles was submitted to twenty experts in the field of elementary science for evaluation as to the suitability of each principle for inclusion as one of the ultimate goals of instruction in elementary science. As a result of this evaluation, the list of principles was refined and reduced to 113.

The investigator then secured "a list of subject-matter topics that are suitable for elementary science, and can contribute to an understanding of scientific principles," by an analysis of five previously completed studies. The list contained 2,324 topics of elementary science which were related to the principles. The principles were further evaluated in terms of their adequacy in answering questions asked about science by elementary-school children. A total of 6,429 questions was collected, of which 5,939 were such that answering them might be considered to contribute to an understanding of a principle or principles.

In 1935 an investigation was made by Nelson [10] under the direction of Robertson at Colorado State Teachers College at Greeley "to determine as objectively as possible, the problems, generalizations, and concepts basic to a secondary science program." An analysis was made of eight books, four of which were surveys of the physical sciences and four of the biological sciences, and the problems, generalizations, and concepts were tabulated.

In this study a generalization was defined as "a general statement arrived at after a careful consideration of the pertinent data." The criteria for the determination of a generalization were:

Does the generalization express a correlation?
Can the generalization be defined objectively?
Does the generalization have a degree of generality useful to the curriculum maker?

A total of 4,910 pages of textual materials was analyzed and 688 generalizations were secured. Of these 155 were from the physical sciences and 503 from the biological sciences.

In 1935 Pruitt [11] made a study under Powers "to determine the concepts and generalizations in the field of chemistry which are of most distinctive value to man in interpreting his environment." An analysis was made of 50,100 pages of printed material including books on science, magazines, newspapers, examination questions and other types of technical and non-technical material, and the chemical concepts and generalizations were listed with their frequency of appearance in all the sources. A list of 135 major generalizations was secured, each of which satisfied the following criteria:

A generalization shall be as simple, comprehensive and definitely stated as possible.
A generalization must be a statement of some fundamental process or constant mode of behavior or property relating to natural phenomena.
A generalization must be true without exceptions within the limitations made in the statement.
A generalization must be a statement capable of demonstration.
A generalization must not be subordinate to a larger generalization.
A generalization must not be a definition.

In 1936 Arnold [12] made an investigation, also under Powers, "to select major generalizations from the field of geology which may be of interest to liberally-educated persons." He analyzed the materials of 5,501 pages in twenty-two books on geology, written by authorities in geology for the general reader; he used the first four of Pruitt's criteria for the determination of the principles. The generalizations secured from the analysis of the twenty-

two books on geology were listed in the order of relative importance on the basis of frequency of appearance in all the sources.

In 1936 a study was made at Colorado State College of Education at Greeley by Moyer [13] " to collect data in the form of diaries of daily-life activities recorded from day to day by a random sampling of the general population, and to evaluate a selected list of principles of biology on the basis of the data collected."

Each biological principle on the selected list conformed to the criterion, " the principle must pertain to the welfare of living things." The evaluation of " the selected list of biological principles " was made " on the basis of the combined occurrence of activities to which they [the principles] are related." The relating of the activities from the diaries to the principle or principles was done in terms of two questions: (1) Does the activity imply a biological principle? (2) In the light of the activity, is there utility value in knowledge of the principle?

The results showed " that the principles which rank highest are those pertaining to food, the common life processes, and the relation of the organism to the environment, while those principles pertaining to heredity, evolution, and the structural phase of the subject seem to have less importance."

In 1936 Olds [14] conducted an investigation at Colorado State College of Education " to determine a list of defensible biological principles that may be used in a secondary-school biology course." The 113 biological principles from Robertson's list were used as the nucleus for this study. Six college biology textbooks were analyzed for principles and those found in the textbooks, but not in Robertson's list, were added to the list. The combined list of 100 biological principles " was then presented to five college science instructors for their constructive criticism." The list of principles was then presented to twenty-one high-school and college instructors in biology for rating as " to suitability . . . as ultimate goals of instruction in secondary school biology." As a result of this study, " ninety-eight defensible major and subsidiary biological principles were found."

In 1941 Wise [15, 16] completed a doctoral dissertation under Curtis, for the purpose of determining " what principles of physical science are most important for general education." In this study a principle was defined in terms of four criteria:

> To be a principle a statement must be a comprehensive generalization describing some fundamental process, constant mode of behavior, or property relating to natural phenomena.
> It must be true without exception within limitations specifically stated.
> It must be capable of illustration.
> It must not be a definition.

The lists of principles of the physical sciences secured in the studies by Arnold [12], Pruitt [11], and Robertson [9], combined with those in a list from a study by Hartmann and Stephens [17], were used as sources in the development of a tentative list of principles. This tentative list was submitted to a jury of two members for evaluation in terms of the criteria set up. A total of 252 principles from the list was judged to satisfy the criteria. This list of principles was then submitted to three subject-matter specialists for an evaluation of each principle " against the investigator's criteria " and with respect to the adequacy and correctness of " the manner of statement of each principle." The final list contained 191 principles of the physical sciences.

Each of the principles in this list was further evaluated on the basis of its applicability to the interpretation of problematic situations commonly encountered in general living. Eleven textbooks, containing materials of the physical sciences and prepared for use at pre-specialization levels, were analyzed for applications. Each application was then assigned to the principle or principles to which it related. A total of

3,403 applications was secured from the eleven books and related to the principles in the list, as a basis for course construction in courses of physical science.

In 1944 an investigation was made by Martin [18], at the University of Michigan, "to determine the principles of the biological sciences which are of importance for general education." In this study a principle was defined in terms of two criteria:

(1) It must be a comprehensive generalization which resumes the widest possible range of facts within the domain of facts with which it is directly concerned. The facts resumed in the generalization must denote

a) objects and/or events and the relations between them

b) properties.

(2) It must be scientifically true. To satisfy this criterion:

a) It must be verifiable; i.e., it must be stated so that it suggests, directly or indirectly, a definite operation of observation or experiment whereby its truth value can be tested or verified.

b) It must be consistent with the body of accepted scientific knowledge, and except for a few limiting or singular exceptions, with all the data (facts) relevant to it.

A tentative list of the important biological generalizations was secured by an analysis of the materials appearing in three junior-college textbooks prepared for survey courses in the natural sciences, three biology textbooks for the secondary school, a survey series of the biological sciences prepared for the general reader, and in the lists of scientific principles in the reports of five research studies. The generalizations were submitted to three specialists in the teaching of science who evaluated each in terms of two criteria: (1) Is the statement a generalization of the *biological* sciences? (2) Is it a *principle?*

The statements which satisfied both criteria were organized into a list of "major" principles; those which satisfied only the first criterion were organized into a list of "minor" principles. The list of major principles was submitted to three subject-matter specialists who were asked to refine the statements, and to judge whether each was scientifically true. The acceptable principles were then organized into a "master" list. The "master" list contained 300 different major principles, and the "minor" list 236.

In the second part of the study an analysis of the scientific materials appearing in selected magazines and newspapers was made to determine which principles in the "major" and "minor" lists must be comprehended in order to permit an understanding of these materials. The major principles, with their related minor principles, were then ranked in descending order on the basis of the frequency of assignment of statements from the articles in these sources to each principle.

Each "major" and "minor" principle was also evaluated, on a five point scale, by selected teachers and laymen as to its suitability for use in a program of general education. The major principles, with their related minor principles, were ranked in descending order on the basis of the values assigned by the evaluators.

SUMMARY

A review of the research studies relating to the scientific principles which are suitable to serve as objectives of instruction in science reveals certain definite trends which are of importance for the organization and presentation of the materials and learning experiences of science instruction for purposes of general education.

In the literature devoted to the discussion of the curriculum in science there are numerous references to scientific principles, but it is difficult and in some cases impossible to find a definite, clearcut statement of the author's idea of what a principle is. Instructional materials, such as textbooks, prepared for use in science classes are often claimed to furnish training in the understanding of scientific principles, but they do not make clear the distinction between

principles, facts, theories, postulates, hypotheses and inferences. In the research studies, however, there is evidence of a definite, progressive refinement of the concept of a scientific principle and of the setting up and utilization of criteria for the determination of the scientific principles.

Along with the refinement in the setting up of criteria there has developed a refinement in techniques for the employment of the criteria, which has tended to render the results secured more objective in nature. The earlier investigators depended on their own judgments exclusively for the final decision as to whether a statement was, or was not, a scientific principle. In later reports the principles secured from the sources were evaluated, in terms of the criteria set up, by several qualified individuals in order to secure greater objectivity of the data.

There is also evidence of an increasing refinement in the methods used for assuring that the final statement of each principle is a technically correct generalization of the facts of the area of science concerned. This refinement is secured by submitting the statements which satisfy the criteria to subject-matter specialists for their judgments as to the technical accuracy of the statements: and by making provisions for them to make any changes in the statements which they deem necessary. Only after the statement of the principle is accepted by these specialists is it considered a principle.

There is also evidence of progressive improvement in the detailed reporting of the methods and techniques employed in the investigations, and of an increasing refinement in the statistical treatment of the data secured.

Thus it is seen that a clarification and definition of the concept of a scientific principle has evolved as a result of the formulation and statement of defensible criteria in terms of which a principle may be determined. Extensive lists of principles which satisfy these criteria have been secured for the various areas of science with which instruction on the elementary and secondary levels of the public schools are concerned, and are available in the reports of several of the studies cited.

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RECENT BOOKS AND ARTICLES

BOOK REVIEWS

BRANDS, GEORGE J. *Meteorology, A Practical Course In Weather.* New York: McGraw-Hill Book Company, Inc., 1944. 235 p. $2.50.

This volume is edited by George J. Brands, chief meteorologist of Pan American Airways System. It includes the basic knowledge of meteorology required of the employees of this company. An illuminating side light into the nature of the book is furnished by the fact that it developed as an outgrowth of a course which these employees are expected to complete without aid from an instructor. The book itself is organized as a series of sixteen lessons which might also be thought of as chapters. Pedagogical aids have been included in the form of illustrations, an extensive glossary, meteorological tables, questions at the end of each lesson, review summaries, and examination questions at the end of each five lessons. Colored-plate illustrations of the basic cloud forms are particularly effective.

The treatment of the various phases of meteorology is descriptive rather than mathematical. At times the treatment seems to be somewhat more comprehensive than need be in an elementary treatise, as for example, the classification of lightning into seven different types. In general, however, the subject matter included is what one would hope to find in a book with the above title.

In the process of building up a backlog of facts and principles basic to the practice of weather forecasting, the author has at times been guilty of introducing isolated fragments of information long before there is any apparent need for them. The discussion of Buys Ballot's Law, for example, might well have been omitted from lesson 1 where it is merely an example of pressure variation in the atmosphere. In discussing winds in lesson 8 the same law is restated and rediscussed in much the same manner as in the earlier lesson. Here, however, it takes on added meaning because of the relation that it expresses between wind direction and the orientation of a low pressure area. The lesson on weather forecasting might have been made more effective if it had included an analysis of a sequence of actual weather charts which illustrate the theory and empirical rules discussed in the lesson.

On the whole the reviewer considers this work to be one of the best short treatises of meterology that has appeared. A lesson on "Cyclones and the Polar-Front Theory" and another on "Frontogenesis and Warm-and-Cold-Front Weather" are indicative of the modern treatment given the subject. The text is very carefully done and with an exactness that inspires confidence. It is recommended to any who have a special interest in weather science. Senior high school and college teachers should find it very helpful either as a text or reference book.

—H. H. WILLIAMS.

BREWER, WALDO LYLE. *Factors Affecting Student Achievement and Change in a Physical Science Survey Course.* New York: Bureau of Publications, Teachers College, Columbia University, 1943. 78 p. $1.60.

This doctoral study had the following five problems: (1) To what extent are factors such as intelligence, initial information, sex, high school attended, and high school courses in science and mathematics related to student achievements, increases in information, and changes in opinions? (2) To what extent can the final marks of a student be predicted from the data available at the beginning of the survey course? (3) How do different lecture and recitation instructors differ in their influence on student achievements, increases in information, and changes in opinion? (4) How well do the final marks divide the students of the survey course into distinctly different groups? How do failing students in the survey course differ from those who receive passing marks? and (5) How do "repeaters" fare in their second experience with the survey course?

To answer these questions, the records of 204 students taking a physical science survey course in Queens College, New York City, were studied. Four instructors taught the course and the students attended 2 fifty-minute lecture sections and 2 fifty-minute recitation sections each week.

Some of the findings include: (1) Students repeating the course showed little measurable gain on a second exposure to the course. (2) Final marks served to divide the students into five rather distinct groups. Each group was significantly different from the one above or below it. (3) Measures taken at the beginning of the course could be used to predict with a high degree of accuracy the final marks of students. The most important of these was the information pre-test. The number of mathematics courses and kinds of science courses taken in high school, and scores on psychological examinations also were of predictive value. Men did slightly better than women, even though they were of slightly lower general intelligence. The best grades were attained by students who had had high-school physics and by those who had the most mathematics courses.

—C.M.P.

POPE, FRANCIS, OTIS, ARTHUR S., AND HUCKEL, O. WENTWORTH. *The Airplane Power Plant.* Yonkers: World Book Company, 1944. 188 p.

This is a most readable treatise on the airplane engine. Many illustrations and half-tones supplement the direct, practically written, textual material. This would seem to be an excellent book for the high school course in aviation and for all boys thinking of entering or who have just entered upon their aviation training.

—C.M.P.

CRAIG, GERALD S. *Science in Childhood Education.* New York: Bureau of Publications, Teachers College, Columbia University, 1944. 86 p. 60c.

Science in Childhood Education presents in an effective way the place of science in the elementary school—its social role, its contribution to the major purposes of the elementary school, and its implementation in harmony with the ideals of our democratic society and the nature and needs of children. Designed as an aid to elementary teachers and administrators, the monograph, number 8 in the series, *Practical Suggestions for Teaching,* edited by Hollis L. Caswell, emphasizes the place of science, through both its procedures and content, in helping children (1) understand and meet intelligently their problems of living and (2) develop desirable social behavior and attitudes.

Discussing the child's growth and development in relation to his environment, the author stresses the importance of (1) utilizing children's natural interest in the incidents and resources of their environment, (2) continuously enlarging and expanding their environment, (3) guiding them in terms of their individual differences, their maturity level, and their particular background, and (4) interpreting the environment correctly in terms of meanings which are beneficial to the individual and society. He points out also the inadequacy of the incidental approach in teaching elementary school science, and suggests a well-balanced program organized around socially valuable problems which at the same time are meaningful and challenging to the children. The basic purposes of science, Dr. Craig impresses, are attained, not through the memorization of specific facts or content, but through "an understanding of the meanings which are essential to the development of desirable social behavior."

The place of community resources as a laboratory for teaching science, and as a means of extending and enriching children's experiences, is discussed. A valuable section of the book describes ways in which various community resources may be utilized, and points out important meanings which should be developed in relation to these resources.

Science in Childhood Education is a significant contribution to educational literature in elementary education and science education.

—DAISY PARTON.

RINDE, CHARLES A. *Electricity and Its Application to Civilian and Military Life.* New York: Harcourt, Brace and Company, 1943. 466 p.

This book is organized around the War Department's outline, "Fundamentals of Electricity." The central theme of the book is the control of electrons. Usually the inductive method of approach has been used in the development of principles. Technical vocabulary has been kept to a minimum. The sixteen divisions have been divided into six units. Suggested experiments are interspersed with the textual material. At the end of each division are a list of "ideas to be reenforced," a quiz on the subject matter of the division, and a list of suggested experiments and investigations. A useful appendix and glossary are found at the end of the volume. Nearly 400 fine illustrations add much to an understanding of the textual material.

—C.M.P.

WILLIARD, LESTER R. *Fundamentals of Electricity.* Boston: Ginn and Company, 1943. 351 p. $1.24.

This is intended as a basic textbook for a one-semester preinduction course. It meets the War Department's outline for a course in the "Fundamentals of Electricity." Many other textbooks have been prepared along this same line, but none has surpassed this one in excellence. It is an excellent companion book to the author's widely used high-school textbook in physics.

Fundamentals of Electricity is interestingly, simply written with a wealth of suggested demonstrations, illustrations, supplementary exercises, and review questions.

—C.M.P.

VAN METRE, T. W. *Trains, Tracks and Travel.* New York: Simmons-Boardman Publishing Corporation, 1944. 417 p. $3.50.

The sixth edition of this popular book on railroading has been enlarged and brought up-to-date. The first two chapters have been rewritten, new information added to others, and a new chapter on "How Our Railroads Went to War" has been added. Many new illustrations have been added.

BOOKS RECEIVED

AUBLE, ROBERT NEIL. *Shop Job Sheets in Radio. Book II. Service Problems.* New York: The Macmillan Company, 1944. 128 p. $1.50.

ARENSON, SAUL B. AND RIVESCHL, GEORGE. *Introduction to Quantitative Analysis.* New York: Thomas Y. Crowell Company, 1944. 386 p. $2.75.

COMSTOCK, JOHN P. *Introduction to Naval Architecture.* New York: Simmons-Boardman Publishing Corporation, 1944. 209 p. $4.00.

GAIL, HARRY R. *Physics Workbook and Laboratory Guide.* Boston: Ginn and Company, 1944. 394 p. $1.32.

MELLON, M. G. *Quantitative Analysis Record Book.* New York: Thomas Y. Crowell Company, 1944. 75c.

BABOR, JOSEPH A. AND THIESSEN, GARRETT W. *How to Solve Problems in Physical Chemistry.* New York: Thomas Y. Crowell Company, 1944. 215 p. $1.25.

DE SOTO, CLINTON B. *Two Hundred Meters and Down—The Story of Amateur Radio.* West Hartford, Conn.: American Radio Relay League. 184 p.

JOHNSON, WILLIAM H. AND NEWKIRK, LOUIS V. *The Electrical Crafts.* New York: The Macmillan Company, 1944. 146 p. $2.50.

JOHNSON, WILLIAM H. AND NEWKIRK, LOUIS V. *Modern Drafting.* New York: The Macmillan Company, 1944. 197 p. $2.50.

SMITH, ELLA THEA AND WEBER, LYNDA M. *Exploring Biology Workbook.* New York: Harcourt, Brace and Company, 1944. 154 p.

ABSTRACTS

JOHNSON, DOUGLAS. "Mysterious Craters of the Carolina Coast." *American Scientist,* 32:1–22. January, 1944.

This article by the late Professor of Geology at Columbia affords one of the best examples of the employment of the scientific method by an outstanding scientist that the abstractor has run across. The article has as its subtitle "A Study in Methods of Research" and it is exactly that. Steps used in trying to answer the problem of the origin of the Carolina craters are described successively: (1) First step: observation and inference, (2) Second step: checking conclusions, (3) Third step: analysis of observations and inferences, (4) Fourth step: analysis of the deductive tests, (5) Fifth step: invention and analysis of multiple hypotheses, (6) Sixth step: deductive testing of multiple hypotheses, and (7) Final step: conclusion.

The meteoritic hypothesis was found wholly incompetent to explain the Carolina craters. A more complex "solution, artesian—lacustrine—aeolian" hypothesis seems more likely, but even this one may be proved false. Only too often is the truth of today revealed in tomorrow's light as an error in disguise. —C.M.P.

YANCH, WILBUR A. "A Defense of Progressive Education." *School and Society,* 60:65–67, July 29, 1944; and

PRATT, KARL C. "Funeral Oration for the Late Progressive Educator." *School and Society,* 60:76–77, July 29, 1944.

The first article laments the sniping at public education and at progressive education in particular. *The Wartime Handbook for Education* by the National Education Association further confuses the issue. The writer believes it is much too early to evaluate the results of the changes which have taken place in the last twenty years. In the first place, not even the wildest enthusiast for Progressive Education claims that more than 3 per cent of the nation's schools practice it effectively. In the second place, even those schools that have made rapid progress in developing an educational program which meets the needs of children have no more than scratched the surface of the most complex problem in human society—adequate guidance of children.

The second article points out that the Progressive Educator worshipped at the altar of the great god Change but he was too impatient at the slow progress made. He was not content that Change be simply inevitable and inexorable. In the passion of his burning zeal he sensed that the god was too slow for "this changing world." His favorite slogans were: "Whatever Is, Is Wrong", "Nothing Could Be Worse Than What We Now Have", "Have You Anything New Today?", etc. The author takes to task those who now wish to conceal their paternity by changing their name to American Education Fellowship. It is whispered that before their father's death his name had come under a cloud and that his children were seeking to escape his burden. Yet only yesterday he was assuring us that he never felt stronger nor more confident of the future. —C.M.P.

ANONYMOUS. "Education of U. S. Armed Forces." *A.A.A.S. Bulletin*, 3:74–75. October, 1944.

The following table indicates the education of enlisted men in armed services.

Grade School	*Number of Men*	*Per cent*
1–8 years	3,170,000	29.4
High School		
One year	940,000	8.7
Two years	1,310,000	12.1
Three years	1,260,000	11.7
Four years	2,670,000	24.7
Total	6,180,000	57.2
College		
One year	560,000	5.2
Two years	370,000	3.4
Three years	180,000	1.7
Four years	330,000	3.1
Total	1,440,000	13.4
Grand Total	10,790,000	100.

Of the 200,000 women in the various branches over 50 per cent had finished at least four years of high school work, 20 per cent had attended college at least one year and 6.7 per cent had attended college four or more years.

—C.M.P.

DARROW, KARL K. "The Future of Physics, Past and Present." *American Journal of Physics*, 12:55–62. April, 1944.

With supporting testimony, the author shows that depression and discouragement characterized the physics of the last four decades of the nineteenth century. Physicists of this period believed that practically everything of importance had been discovered; all fundamental laws were believed to be known. The next four decades have been a period of great activity and anticipation. The author detects possibly another period of depression in which some will suppose that the phenomena of nature have been so thoroughly combed that nothing strange, nothing novel, nothing curious and nothing unforeseeable remains to be discovered. —C.M.P.

FULLER, J. OSBORN. "Clouds." *The Journal of Geography*, 43:132–139, April, 1944.

This is an interesting illustrated article presenting materials that may be taught regarding clouds. An excellent chart lists the kinds of clouds, their elevation, color, form, composition, precipitation, and location.

—C.M.P.